SPECIAL FEATURE ON DIGITAL SIGNAL PROCESSING

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GUIDE TO ELECTRONICS FAULTFINDING

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AUSTRALIA'S LARGEST SELLING ELECTRONICS MAGAZINE – ESTABLISHED IN 1922

Military communications

What can you do when your important military communications signals are being jammed? Why, keep hopping all over the frequency spectrum, of course – as our article on page 10 explains.

Projects to build

Our construction projects this month include an improved VHF-UHF masthead amplifier for TV and FM reception, the long-awaited Super Timer (finally!), the receiver-decoder section of our 16-channel UHF Remote Control, and the two core boards for our Real World PC Interface.

DSP feature

Digital signal processing techniques are coming into much wider use, thanks to the development of new specialised computer chips. Learn more about DSP and the new chips in our special feature starting on page 116.

On the cover

Tracking down faults in electronic gear isn't hard, if you follow some simple rules – see page 28. EA staff engineer Rob Evans is shown checking an electronic phone. (Photo by Peter Beattie)

Features

Entertainment Electronics

Projects and Technical

News and Comment

Departments

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Letters to the editor

Electrostatic speakers

Following the comments of Steven Robinson regarding your review of the book "Electrostatic design and construction" by Ronald Wagner, I can only agree with the comments Steven has made and after designing and building electrostatic speakers myself for the last 20 years would like to add a few comments of my own to the subject.

Firstly the electrostatic panels in the book design would have the defects indicated by Steven but not necessarily from the choice of diaphram material as he indicated. The author used a set of design parameters using a fixed spacing design. It can be shown that the three high frequency drivers will be directional, because the diameter to length ratio of these drivers is not optimised but is of a uniform length to ease construction. If the drivers are constructed to the dimensions in my own calculations, it will be found that the radiation angle will approximate 90 degrees which is as good as can be expected from designs without the use of multiple angled drivers or doublets to determine the radiation pattern.

Secondly no absorbent material is used in the design to reduce rear radiation at high frequencies, and if some absorbent material is used this will improve the image substantially as Peter Walker has researched.

Thirdly the author has designed each individual panel with a resonant frequency of one octave below the design cutoff frequency. Without the use of a bandpass filter to drive each section this can only result in a far from flat response and no matter how much mechanical damping one may introduce the fundamental problem will still exist. Fortunately the solution is a simple one in that a first or second order RC bandpass filter can be constructed to substantially reduce the levels at the resonant frequency. At the low frequency end of the spectrum the design can be modified to trade off some efficiency for an improved low frequency performance.

The fourth design problem involves the obvious lack of calculation or measurement of the capacitance of each panel, so that the correct value of series resistance can be calculated for the low pass filter sections of his crossover. It can be shown that the crossover frequencies at the high frequency end are incorrect as the same value series resistors (390K) are used for each section. And this value will be determined by the amount of open space of the plates used.

Problem number five is the use of one diaphram for the entire passband. Here intermodulation distortion products will result from non linear piston displacement, as the high frequency drivers are not being used to provide diaphram displacement equal to that at the centre of the driver. The solution here is also a simple one in that the placement of additional spacers between the low frequency sections and the mid-high frequency drivers will stop these drivers being modulated altogether by the low frequency panels.

If one uses the above design changes a satisfactory result should be obtainable.

Two further notes for prospective constructors. As the power content in each part of the spectrum differs with musical content two audio transformers could be used in place of one wide bandwidth unit. In practice I have used valve guitar amplifier output transformers in reverse to drive the bass drivers and grain oriented Hi-Fi push pull 6GWB type output transformers for the high frequency drivers. This also allows simple conventional crossovers to be used at the voice coil impedance level for better bandpass characteristics.

Also if you are looking for a manufacturer of mains or output transformers a small company in South Australia (Bland Sales & Service, at 14 Forsters Rd, Ridleyton) will wind custom transformers at a reasonable price.

Notwithstanding the above comments I would highly recommend the purchase of "Electrostatic Loudspeaker Design and Construction" and believe that the information therein is a valuable addition to any bookshelf. Secondly I would also refer interested parties to two other articles published, one in *Elektor*, September 1981 about the ESL-63's, and the second an article in *Electronics Australia* in February and March 1976 about building electrostatic tweeters.

Graham Dicker
Blackwood, SA

MEK danger

In the March 1988 issue there was a letter in which a correspondent states that he uses MEK to clean PCB's. I enclose an extract from the Australian publication "Aviation Safety Digest" which should be brought to the notice of anyone contemplating the use of this solvent.

Please publish this extract as a contribution to safety.

Max Riley, VK2ARZ
Mortdale Heights, 2223

Here is the extract:

EYESIGHT IS PRECIOUS

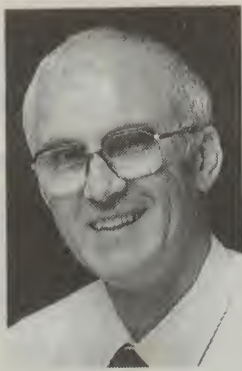
At a recent safety conference, an eye specialist described a hazard that could affect each of us and our families. That hazard is the catalyst or hardener added to fibreglass resin before the resin is applied. The eye specialist stated that a drop of this catalyst in the eye will progressively destroy the tissue of the eye and result in blindness. This will occur even though an attempt is made to wash the catalyst from the eye. Furthermore, once the chemical has started to destroy the eye, there is no known way of stopping the destruction or repairing the damage.

The specific toxic agent involved is methyl-ethyl-ketone peroxide (MEKP). In laboratory tests, MEKP in solutions of varying concentrations was found to cause eye problems ranging from "irritation" to "severe damage". The maximum concentration producing no appreciable irritation was a solution containing only 0.6% MEKP. Material published on the subject indicates that washing an affected eye within four seconds after contamination prevented injuries in all cases, but no known chemical neutralizer has been discovered. Suggested precautions for catalyst users are eye-protective spectacles and the immediate availability of a source of bland fluid such as water for thorough washing of ocular tissues.

One disastrous experience was described. While fibreglassing a chair at home, a victim had both eyes contaminated by MEKP. Though he made an effort to wash his eyes out, several minutes apparently elapsed before he found water. The sight of one eye was lost immediately, the other was lost gradually over a period of about eight years. Its deterioration was described as resembling that resulting from mustard gas burns during World War 1.

This fibreglass resin danger was previously unknown to those attending the conference, though many had used fibreglass resin at work or at home. The haz-

(Continued on page 137)



Editorial Viewpoint

The year that was, and the better year ahead

Here we are again, nearing the end of another eventful year. How time flies when you're having fun – and/or working hard!

Actually this year has been a little more eventful for *EA* than any of us would have wished. That holocaust a few months ago in our office building really set us back quite a bit, and for much longer than most of you probably realised. As I write this we're still working from two tiny and incredibly jammed rooms in what's left of the old building, and only due to move into our new temporary quarters shortly. We'll be there for quite a lot of next year, while the main building is knocked down and rebuilt.

One of the really distressing things about the fire was that directly or indirectly it caused production delays, which filtered down through the printing, binding and distribution stages – generally growing longer in the process (Murphy's Law, I guess!). And the end result has been late arrival of quite a few issues, not just on the news stands but for subscribers as well.

This has been incredibly frustrating for everyone concerned, and I can't blame those incensed readers and subscribers who wrote in to complain. But to the many others who have accepted the delays with nary a murmur, please accept our grateful thanks for your patience and understanding.

Needless to say we've all been working extremely hard to overcome the obstacles and get everything back on time, and I'm fairly confident that we're just about there now.

In fact – dare I say it? – next year is really beginning to look quite promising. We're now working with a full editorial team again, augmented by our regular contributors. There are lots of interesting construction projects in the pipeline, plus plenty of helpful general articles for both newcomers and old hands alike. All in all (and barring further fires, floods or hurricanes), I'm confident we're going to have a great deal to interest and help you in 1989 – our 50th year as a monthly, and our 67th year of continuous publication. So stick with us, the best is yet to come!

And in the meantime, from all of us labouring here at the makeshift *EA* offices, to all of our many readers, contributors, advertisers and friends: our very best wishes for a Merry Christmas and a Happy New Year.

Jim Rowe

What's New In Entertainment Electronics

Wall-mount hi-fi speaker

Jamo Art is a new high-performance loudspeaker from one of the world's leading loudspeaker manufacturers. Similar in size to a 20″ TV screen, the design is super flat and very elegant. But the sound reproduction is anything else but flat: it is claimed to be full and dynamic, with clear resonance-free bass.

Despite its size and flat square appearance, the internal cabinet volume is surprisingly large. Jamo Art is designed to be wall mounted. In so doing, the cabinet is acoustically coupled to the wall, enabling it to reproduce the deepest possible bass from the compact enclosure design.

It is almost impossible to make a flat loudspeaker using conventional production techniques. The front panel of Jamo Art is made of a one-piece injection moulded ABS material, reinforced by a complicated computer-optimised pattern of ribs for optimum stiffness of the front panel. The back panel is a form-pressed heavy steel plate which, on the inside, is covered with a synthetic foam material for optimum damping. The front and back plates are screwed together locking the two drivers in position, eliminating any resonances.

This newly developed 2-way loudspeaker utilises a rubber roll surround 5″ woofer for the bass and midrange area. It is efficient and has very low distortion.

To further enhance the bass response Jamo Art is an integrated bass reflex cabinet. The bass reflex port has been designed as an integral canal.The bass reflex opening has been positioned on the rear side of the cabinet so the bass output through the port is further enhanced by the wall itself. A new 1″ impregnated textile dome tweeter provides wide dispersion. The loudspeaker is suitable for amplifiers with an output of 30-90 watts per channel. The frequency response is quoted as 40-20,000Hz.

For those who desire a more conventional looking loudspeaker, a bookshelf version of Jamo Art is also available. This speaker is called Monitor-One and is finished in either black or white lacquer. The components used are identical, and technical data is very similar.

As the lowest octaves in e.g., classical music are difficult to reproduce without having very large speaker cabinets, Jamo has developed an active subwoofer to match either enclosure. The subwoofer has a built-in 55 watt amplifier and is connected directly to the amplifier in parallel with the main speakers.

The SW-50 subwoofer is finished in either black or white lacquer, and can be positioned anywhere in the room, as low frequencies are non-directional.

For further information contact the Sole Australian Distributor, Scan Audio, 52 Crown Street, Richmond 3121 or phone (03) 429 1299.

Sound reinforcement system

Audio Engineers has introduced the Shure Audiomaster, a compact sound system with optional six, eight or ten inputs and 200 watts of power.

The Audiomaster system consists of the Audiomaster 1200 Mono Powermixer which is a mixer/amplifier with six inputs, which can be expanded to eight or ten inputs. Power output is 200 watts minimum with 4-ohm speakers and 120 watts with 8-ohm speakers. It weighs 12 kilos, is 7″ high and mounts in a standard 19″ rack. There are separate monitor and reverb mixes and concentric EQ controls for each input and monitor mix.

There are a range of compatible options such as the 3200 Speaker, the 1200 MX Expansion Module, carrying cases, microphones and speaker cable to make the Audiomaster system a flexible, rugged, compact and high-quality sound reinforcement system.

For further information contact Audio Engineers, 342 Kent Street, Sydney or phone (02) 29 6737.

Sony products for kids

Kids as young as 4 now have a selection of 'My First Sony' products to call their own. The product line includes a 2 unit walkie-talkie headset, (ICB-1000) a cassette-recorder with microphone for children's home recording, (TCM-4000) a radio cassette recorder with AM/FM tuner (CFM-2000) and a child's version of the one and only Sony Walkman – or should it now be called 'Toddleman'? (WM-3000).

The walkman comes with a volume limiter switch that, when turned on by Mum or Dad, restricts the volume level to protect tiny ears even though the child may have the normal volume control turned to maximum. It also has a see-through back panel with colourful working parts.

The walkie-talkie set is Department of Communication permitted and operates to a distance of 300 metres depending on land formation and building interference.

The radio cassette player has an AM/FM tuner, a cue and review function, rounded corners, a big moulded handle and big colour coded buttons for tiny hands to operate.

Last, but knowing Sony not least, is the recorder music machine designed to let budding stars sing along with their favourite artist or record their own composition.

All four 'My First Sony' products are lightweight and durable with a sturdy plastic shell in colourful combinations or red, blue and yellow with big soft touch buttons for easy identification and operation by young fingers.

ABC instals local speakers in Lismore studios

Shown here is part of the studio equipment from Audiosound Laboratories at the new ABC studio complex in Lismore NSW.

Main studio monitors are the 8035 extended bass system, offering sub-woofer performance with a very smooth time aligned top-end at a fraction of the price of fully imported systems.

Other monitors used are the 8025 mini-monitor, which though quite small has a -3dB point at 50Hz; the 8011A; and for general purpose program monitoring the Audiosound Laboratories 8002's are used.

Also supplied were the new PM60 2 unit balanced input MOSFET power amplifiers, which offer high performance and reliability at a modest price.

For further information contact Audiosound Laboratories at 148 Pitt Road, North Curl Curl 2099 or phone (02) 938 2068.

New cartridge, amplifier from Ortofon

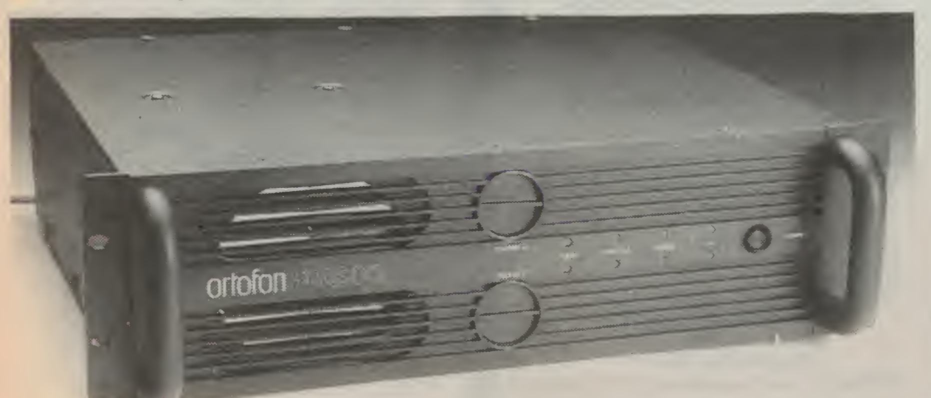
To celebrate the company's 70th birthday, Danish hi-fi maker Ortofon has announced a new cartridge and its first-ever power amplifier.

The Anniversary Cartridge, which, not surprisingly, has been named MC70, has been developed using the knowledge and expertise gained in the production of the MC3000, and with majority of the high quality materials that were incorporated in this top-line cartridge. Only minor changes have been made: a somewhat modified rubber bearing and the diamond has been ground with a slightly different radius.

In spite of the quality level and price (calculated at approx. 25% less than the MC3000) Ortofon has elected to produce and sell only 800 pcs of this product. Each MC70 will be numbered from 1 to 800. The number is engraved on the topside of the cartridge, and printed on the ceramic plate, inside the box lid, on the reverse side of the owner's manual, and, finally, it is written on the B&K graph giving the specific data.

Ortofon's first power amplifier, PPA600, has been developed over the last year in close collaboration with the firm's Italian distributor. It has been thoroughly tested, and the first 50 units produced.

Features include 225W per channel output into 8-ohm loads (both channels driven), 40A peak output current capability and all-metal 19" rack construction.



Entertainment Electronics

Sanyo Video-8 camcorder

Sanyo Australia is particularly proud of its new advanced VWD-5P camcorder, which boasts such features as variable shutter speeds from 1/50th of a second through to 1/4000th of a second.

Other features include digital two zone autofocus, a more advanced type of focusing for clearer images, even through glass; 6 times power zoom with macro function; auto back-light; 9 times and 21 times forward search as well as 7 times and 19 times reverse search. And of course, features such as slow motion frame advance, still picture and tape counter are also included. Dual voltage for overseas travel is another handy feature.

Another novel feature on this model is a title inserter enabling the user to professionally insert movie titles at the beginning of recording in a choice of colours of white, blue , red, yellow and/or black.

Complete with hard carry case and accessories the VWD-5P camcorder has an RRP of $3299.00

'Intelligent' CD player

Marantz has released its super-smart model CD75DX CD player. The CD75DX includes 'Favourite Track Selection', a device which allows pre-programming of up to 226 discs. The FTS memory stores information on the preferred tracks on each disc; it then identifies the disc and automatically plays the selected numbers every time the disc is inserted into the player. The selections can easily be changed, or the FTS memory can be over-ridden and the complete disc – or any part of it – played at will.

The CD75DX also has sophisticated conventional programming of individual discs. The player can directly access up to 99 tracks, with random access memory for 20 tracks. Programming can be by track, index or time – and can be done from the CD75DX's remote con-

'Super' mini earphones

Arista Electronics has supplemented its extensive range of high quality headphones and other audio accessories with the new 'super-mini' earphones Model No. EPS-200.

The EPS-200s are suitable for use with all digital equipment including CD DAT and are naturally also suitable for use with analog hi-fi equipment. Features include a samarium cobalt magnetic transducer, and a 1.25m high quality shiedled cable with a gold right angled plug to make a solid connection. The EPS-200's fit into a dispenser type protective black carry case which fits neatly into a purse or a pocket for safety and portability.

The individual left and right earpieces of the EPS-200's are specially designed to fit comfortably into most ears and deliver clean crisp sound direct to even the most discerning ear. They carry a recommended retail price of $39.99.

For further information contact Arista Electronics, 57 Vore St, Silverwater 2141 or phone (02) 648 3488.

remembers favourite tracks

trol. The remote control also allows adjustment of volume from the armchair.

Designed and built in Europe, the CD75DX is claimed to be one of the most technically advanced players on the Australian market, with twin 16-bit digital-to-analog converters and three separate power supplies to ensure signal purity and delivery of the truest sound.

Provision of four-times over-sampling and digital filtering removes the need for steep analog filtering which can upset the dynamic performance and stereo image. The ultra-compact single-laser beam assembly is mounted on the latest fully floating die-cast mechanism. With a low moving mass it has fast access times, high tracking stability and much reduced susceptibility to acoustic feedback.

The CD75DX has optical and electronic digital outputs for direct connection to separate digital processors, such as Marantz's CDA94.

New Akai VCR has Dolby Surround Sound

Dolby Surround Sound offering concert hall realism has now been brought into the home, than'ks to Akai. The company's new VS-A.'7 HQ hi-fi stereo VCR incorporates a host of technological developments including Dolby Surround Sound, hall surround, synthesised stereo, built-in 10W stereo amplifier, universal remote control and a host of of other features.

Mr John Karbowiak, national sales manager of Akai Australia, says that "although there are simpler surround sound systems using variations of third or phantom channel concepts, the VS-A77 uses the motion picture Dolby Stereo System".

"Such complex surround decoders were first available only in expensive motion picture theatre projection and professional equipment. You normally had to attend the cinema to experience the feeling. The Akai Dolby Surround System VCR brings this realism within the reach of the domestic consumer".

The synthesised stereo feature inverts the phase of the rear speakers and delays the rear channel by 20 milliseconds. This can be used on mono transmissions and videos to recreate a pseudo stereo effect.

The VS-A77 is a full HQ stereo hi-fi VCR incorporating Akai's DX-4 head system. The double azimuth crystal ferrite heads are claimed to deliver stunning picture quality in both SP and LP modes.

A look at 'jamming', 'frequency hopping' etc:

The changing face of Military Communications

Good communications may not win a war, but poor communications can certainly lose one. Ian Graham reports here on the radio technology of today's electronic warfare.

Radio is a key element in the business of moving information around. But radio signals do not discriminate between receivers. Essentially they can be received by allies and enemies alike.

Military forces face the problem of feeding information from dispersed mobile radio transmitters at the fighting front to command centres reliably, without allowing the same information to fall into enemy hands.

A great deal of time, effort and money have been invested in developing ways of denying the enemy access to communications. This electronic cat-and-mouse game has hotted up considerably in the past ten years, as the cost of computer memory and digital electronics has fallen. Because of this, each new generation of communication equipment can be both cheaper and more versatile than its predecessors.

Racal-Tacticom's BCC39 military radio communications systems can transmit voice and data on any of 285,000 channels.

Computers are numerical creatures. Even the most sophisticated computers at the heart of talking, seeing and hearing robots work by processing numbers. Modern weapons invariably use computers at some point in their aiming, firing, guidance or detonation. This huge increase in the use of 'number-crunching' computers means that it has become very important for military forces to be able to transmit and receive numbers very rapidly and reliably. Some would say that this is now more important than voice communication.

Whatever the source of the information – printed text, spoken words, computer data, etc – it can be digitised before transmission. That is, it is converted into a stream of pulses. The rapid stream of pulses is converted back into its original form by the receiver.

This 'digital' transmission resists interference better than the alternative of analog transmission. As long as the digital pulses can be detected by the receiver, however degraded or distorted they may be, the voice or printed text that they represent can be recreated almost perfectly.

In contrast an analog signal, which represents information as waves of radio energy changing in frequency or magnitude, would be severely degraded and perhaps totally unintelligible if subjected to the same amount of interference.

Encryption

One way of preventing the enemy from reading the contents of messages transmitted is to scramble the messages, a process called *encryption*, which is nowadays carried out by computer. But the techniques are equally well known by everyone in the electronic warfare business, so enemy computers can be used to identify the particular encryption technique or combination of techniques used, and begin to unravel the coded message.

There is a further complication. If you've ever brought an ordinary radio set within a few feet of a personal computer, you'll be aware that computers themselves transmit radio waves. The receiver picks up a mish-mash of noise from the computer. Subtle changes in the frequency of this generally unwanted radio 'noise' reflects what the computer is actually doing.

A suitably equipped 'eavesdropper' can pick up this noise with a radio receiver and in theory at least convert it back into intelligible information.

In this way, it is possible to read what a computer operator some distance away is typing into the computer. The radio signals transmitted by the computer are received by a radio and fed into another computer programmed to turn them back into text on the screen.

'Tapping' a computerized military communications system in this way enables the interceptor to read what a soldier is typing into his terminal before it is encrypted and transmitted. To do this successfully, the interceptor has to get close enough to the terminal to pick up the low-power signals being transmitted by its keyboard. Designers make this even more difficult by shielding military computer terminals to a much higher degree than home or office personal computers, greatly reducing the amount of radio energy that they broadcast.

Even if a message is encrypted so that the enemy cannot understand it, all the effort is wasted if the signal is jammed – because then no-one can receive it!

In the same way that a spoken message can be swamped by loud music playing nearby, a radio signal can be jammed by transmitting a stronger signal on the same frequency. Once a signal has been jammed in this way, the only way to resume communications is to change frequency. The jammer then homes in on the new frequency. If the communicators can change frequency more quickly than the jammer, communications can continue.

Radio equipment designed to seek out and jam radio signals does the job so quickly that the repeated re-tuning necessary to keep one step ahead of the jammer and maintain communications has to be done automatically too, under the control of computers. There are two types of 'frequency hopping' as this rapid frequency-changing is called – *orthogonal* and *non-orthogonal*. The first of these ensures that signals from different communications networks are always kept apart on different frequencies to minimise interference. The second doesn't attempt to keep the signals apart. As a result some interference is possible as the radios can momentarily transmit on the same frequency, effectively jamming each other.

In practice, because frequency-hopping radios have between several hundred and several hundred *thousand* different frequencies at their disposal, signals rarely hop onto the same frequency. Even when they do, the two signals only overlap for a fraction of a second and so interference is negligible.

If the jammer can't follow the frequency hopping radio quickly enough to disrupt communications, one answer is

Racal-Tacticom's Jaguar, the world's first frequency-hopping radio, was launched in 1982 and is now used in 30 countries.

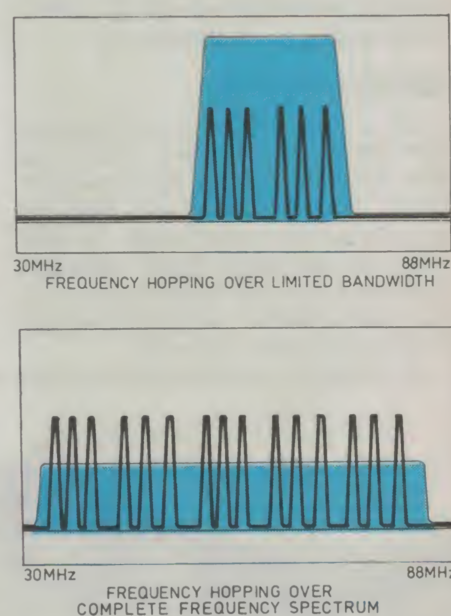


Fig.2: Frequency hopping over a narrow range can be easily jammed (top), but hopping over a wide spectrum makes it much harder by dissipating jammer power (above).

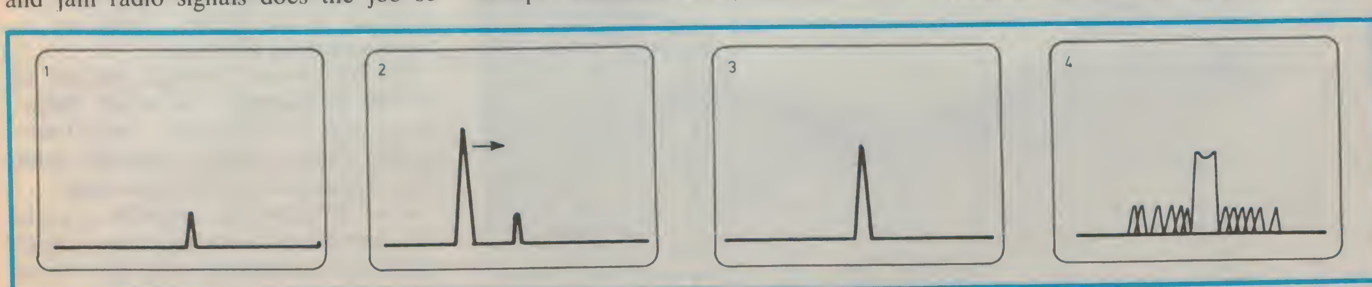


Fig.1: Evading jamming by frequency hopping. A fixed low power signal (1) can easily be homed in on by a jammer (2) and obliterated (3). But if it hops around the spectrum, even a wideband jammer has problems.

to jam the whole waveband. However quickly the radio hops about, the jammer swamps all the frequencies that are likely to be used. But there is a limit to the amount of energy that a jammer can transmit.

So for a given jammer power output, the greater the number of different frequencies that are jammed, the smaller is the power level of the jamming signal at each frequency. This makes it easier for the communications signal to break through, because unlike the jamming transmitter, its transmitter can devote all its power to transmitting on just one frequency at a time.

Increasing the bandwidth of the communications network as much as possible also makes things more difficult for the jammer. If the communications channel is broad enough, the jammer simply can't cover all the available frequencies powerfully enough to obliterate everything being transmitted.

The Marconi Scimitar comms system provides digital data and voice comms, hopping automatically over 284,000 channels to evade jamming.

Using satellites

Of course, military communications now extend out into space. On the face of it, satellites are very weak communications links in time of war. They can be knocked out quite easily. In most cases they're sitting ducks, stationary with respect to the earth's surface and very easy to locate and destroy by relatively crude missiles or lasers.

Yet military communications networks frequently use satellites to collect information and relay it around the world. Satellite communications terminals can now be made small and light enough for a soldier to carry around with him in a back-pack – Ferranti's 'Mansat', for example.

Military analysts are of the opinion that satellites will probably remain relatively untouched during a conflict. A satellite war would affect both sides and ultimately would be likely to prolong a conflict, due to the reduction in intelligence gathering.

So each side would be reluctant to embark on anti-satellite activities. Or at least that's the theory! Nevertheless, the vulnerability of satellites is taken into account. Satellite communications circuits are usually duplicated by ground-based circuits, in case a vital satellite link is knocked out.

Special forces such as Britain's Special Air Service Regiment (SAS) and the Royal Marines Special Boat Squadron (SBS) have particular requirements for radio equipment. These special forces need to be highly mobile and difficult to locate, and so they require radios that are very small, lightweight and more versatile than the standard infantryman's radio.

The Racal-Tacticom BCC39 radio system, for instance, consists of a series of modules. Troops need only carry the modules needed for a particular mission. The basic 50-watt transceiver weighs only 2.3kg. It can also be mounted in a vehicle, doubling its power output to 100 watts.

The BCC39 can transmit on any of 285,000 frequencies. To evade detection, it can be used with a 'burst transmission device' which transmits short bursts instead of a continuous signal.

New developments include a radio that can transmit on a frequency so high that it makes molecules of oxygen in the atmosphere vibrate. Every material has a natural frequency at which its molecules will vibrate very easily, called its

Racal-Tacticom's new TSC 501 satellite comms terminal. Two men can can have it set up and running in less than 10 minutes.

resonant frequency. Radio energy is most easily absorbed by a material when it is at the material's resonant frequency.

For this reason, radio communications systems normally avoid the resonant frequencies of the gases and vapours normally found in the atmosphere, because transmitted radio signals would be absorbed by the atmosphere and dramatically reduced in power before reaching the receiver.

However, special forces requiring secure communications over relatively short distances, perhaps behind enemy lines, may not wish their communications to be broadcast further than a few kilometres. The latest direction-finding systems need to receive a radio signal for only a few milliseconds to locate its source.

The resonant frequency of oxygen in the atmosphere is 60 gigahertz (60 thousand megahertz). Transmitting radio signals at this frequency therefore ensures that they are rapidly absorbed by atmospheric oxygen, so they do not travel very far.

Hardened hardware

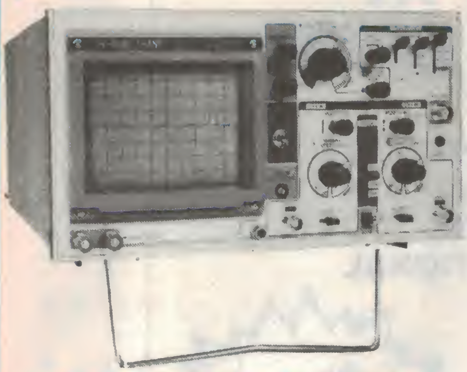
Military radio networks may have to contend with more than difficult combat conditions and interception by hostile receivers. If a nuclear war ever begins, most of the radio, television and computer equipment in our houses and offices will be effectively destroyed by the enormous burst of electromagnetic radiation that will stream out from each explosion – called *ElectroMagnetic Pulse* (EMP). Military systems have to be 'hardened' against EMP.

Future battlefields will rely heavily on electronic information gathering and interpretation. Remotely piloted vehicles (unmanned aircraft) will relay television pictures of troop movements to command centres. Pictures taken by satellites and cleaned up by computer will enable commanders and politicians to monitor military activities in several parts of the world at once.

The battlefield will be peppered with electronic listening devices and radio jamming equipment delivered with pinpoint accuracy by aircraft, guided missiles and artillery shells. Computerised communications networks will detect a failure occurring anywhere in the network and automatically re-route communications signals around the problem.

This is no science fiction scenario – the technology exists now and is already in use in many parts of the world.

MERRY CHRISTMAS



HUNG CHANG (RITRON) 20 MHz DUAL TRACE OSCILLOSCOPE

- Wide bandwidth and high sensitivity
- Internal graticule rectangular bright CRT
- Built in component tester
- Front panel trace rotater
- TV video sync filter
- Z axis (intensity modulation)
- High sensitivity X-Y mode
- Very low power consumption
- Regulated power supply circuit

COMPONENT TESTER is the special circuit with which a single component or components in circuit can be easily tested. The display shows faults of components, size of a component value, and characteristics of components. This feature is ideal to troubleshoot solid state circuits and components with no circuit power. Testing signal (AC Max 2 mA) is supplied from the COMPONENT TEST IN terminal and the result of the test is fed back to the scope through the same test lead wire at the same time.

CRT
CRT: 6 (150mm) Flat-faced high brightness CRT with Internal Graticule
Effective display area: 8 x 10 div (1 div 10 mm)
Acceleration potential: 2KV

VERTICAL
Operating Modes: CH-A CH-B. DUAL ADD (CH-B can be inverted.)
Dual modes Alter 0 2ufs - 0 5ms div Chop. 1ms - 0 5s div
CHOP frequency 200KHz approximately
Deflection factor: 5mV div 20V div - 3% 12 ranges in 1-2-5 step with fine control
Bandwidth: DC DC - 20MHz (3dB) AC 10Hz - 20MHz 3dB)
Rise Time: Less than 17ns
Overshoot: Less than 3%
Input Impedance: 1M ohm · 5% 20pF · 3pF
Maximum Input Voltage: 600Vp-p or 300V (DC · AC Peak)
Channel Isolation: Better than 60 dB at 1KHz

HORIZONTAL
Sweep Modes: NORMAL and AUTO
Time Base: 0 2ufs - 0.5s/div · 3% 20 ranges in 1-2-5 step with fine control
Sweep Magnifier: 5 times (5X MAG)
Linearity: 3%

TRIGGERING
Sensitivity: INTERNAL: 1 div or better for 20Hz - 20MHz (Triggerable to more than 30MHz). EXTERNAL: 1Vp-p or better for DC - 20MHz (Triggerable to more than 30MHz).
Source: INT CH-A. CH-B. LINE and EXT
Slope: Positive and Negative. continuosly variable with level control PULL AUTO for free-run
Coupling: AC. HF-REJ and TV. TV SYNC Vertical and Horizontal Sync Separator Circuitry allows any portion of complex TV video waveform to be synchronized and expanded for viewing TV-H (Line) and TV-V (Frame) are switched automatically by SWEEP TIME/DIV switch.
TV-V 0.5s/div to 0.1ms/div. TV-H 50ufs/div to 0.2ufs/div

X-Y OPERATIONS
X-Y Operations: CH-A: Y axis. CH-B: X axis Highest Sensitivity 5mV/div

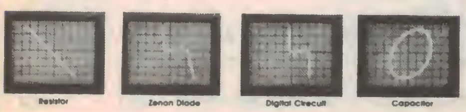
COMPONENT TESTER
Component Tester: Max AC 9V at the terminal with nc load. Max current 2mA when the terminal is shorted. (Internal resistance is 4.7K ohm)

OTHER SPECIFICATIONS
Intensity Modulation: TTL LEVEL (3Vp-p): Positive brighter
BANDWIDTH: DC - 1MHz MAXIMUM INPUT VOLTAGE 50V (DC + AC Peak)
Calibration Voltage: 0.5Vp-p +/- 5%. 1KHz +/- 5% Square wave
Trace Rotation: Electrically adjustable on the front panel.
Power Requirements: AC: 100. 120. 220. 240V 20W
Weight: 7kg approximately
Size: 162(H) x 294(W) x 352(D)mm.

Cat. Q12105 .... **only $895**

(tax exempt only $775)

Bulk orders, schools, please phone (03) 543 2166 for special low pricing



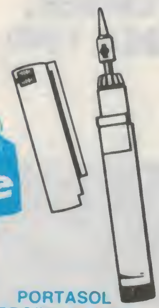
ARLEC SUPER TOOL

A versatile 12V electric tool for...
- Sanding
- Engraving
- Grinding
- Polishing
- Cutting
- Drilling
- Milling
- Erasing, etc.

Features:
Operates on safe, low 12 volts from mains electricity via AC adaptor (supplied). Light and easy to handle with touch switch and lock for continuous running. High torque motor 10,000 R.P.M. Can drill 2mm holes in steel. 2 year guarantee

Contents:
- 12V Super Tool
- Plugpack AC adaptor
- 1 spherical milling cutter
- 1 wire brush
- 1 grinding wheel
- 4 drill bits. 0.6, 0.8, 1.0, 1.2mm
- Set of 5 chuck collets
- 6 eraser sticks
- Instruction sheets

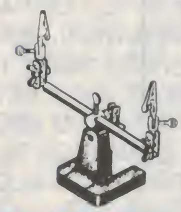
Cat. T12300 **$64.95**



PORTASOL PROFESSIONAL

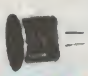
- Four tools in one: Blow Torch, Hot Blow, Hot Knife
- No Cords or batteries
- Heavy duty, tip temperature adjustable up to 400°C
- Equivalent to 10-60 watts
- Hard working. Average continuous use 90 minutes
- Refills in seconds
- Powered by standard butane gas lighter fuel
- Range of easily replaceable screw tips included
- Includes metal stand for the soldering iron when working
- Cap features built-in flint for igniting Portasol tip
- Includes snap case for storage

Cat. T12639 **$89.95**



PC BOARD HOLDER

Better than an extra pair of hands! A must for all PCB work
Cat. T12444 **$9.95**



ELECTRET MIC INSERTS

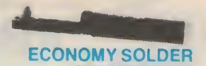
With pins for easy board insertion.
Cat. C10170

1-9	10+	100+
$1.20	**$1.00**	**$0.90**

FOOT SWITCHES

- Momentary or on/off models to choose from
- Cord length 2·5 metres
- 6·3mm plug

A17000 Momentary operation
A17005 Push On/Off operation
each $19.95



ECONOMY SOLDER SUCKER

- Light weight
- Sturdy construction
- Easy to remove tip
- Excellent value for money!

Cat. T11271 .... **$11.95**

ECONOMY ANTISTATIC SOLDER SUCKER

- Light weight
- Sturdy construction
- Easy to remove tip
- Excellent value for money!

Cat. T11281 .... **$13.95**

MAIL ORDER HOTLINE
008 335757
(TOLL FREE)
LOCAL: 543 7877

BELL WIRE

Red and white twisted
Conductors: 2 x 1 strand 0.17mm
Sheath: O.D. 2 x 1.35mm
Cat. W

1-9 rolls	10+ rolls
$19.00/m	**$17.50/m**

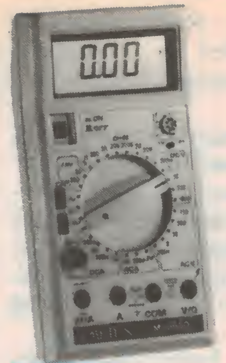
METEX 3530 MULTIMETER

This instrument is a compact, rugged, battery operated, hand held $3\frac{1}{2}$ digit multimeter for measuring DC and AC voltage, DC and AC current, Resistance and Diode, Capacitance, Transistor hFE and Continuity Test. The Dual-slope A-D Converter uses C-MOS technology for auto-zeroing, polarity selection and over-range indication. Full overload is provided. It is an ideal instrument for use in the field, laboratory, workshop, hobby and home applications

Features...
- Push-button ON/OFF power switch
- Single 30 position easy to use rotary switch for FUNCTION and RANGE selection
- $\frac{1}{2}$" high contrast LCD
- Automatic over-range indication with the "1" displayed.
- Automatic polarity indication on DC ranges.
- All ranges fully protected plus Automatic "ZERO" of all ranges without short circuit except 200 ohm Range which shows "000 or 001"
- High Surge Voltage protection 1.5 KV-3 KV
- Capacitance measurements to 1pF
- Diode testing with 1 mA fixed current.
- Audible Continuity Test.
- Transistor hFE Test

SPECIFICATIONS
Maximum Display: 1999 counts $3\frac{1}{2}$ digit type with automatic polarity indication.
Indication Method: LCD display
Measuring Method: Dual-slope in A-D converter system
Over-range Indication: "1" Figure only in the display
Temperature Ranges: Operating 0-C to +40-C
Power Supply: one 9 volt battery (006P or FC-1 type of equivalent)

Cat. Q91540 .... **Normally $139**
SPECIAL $109



METEX M-3650 MULTIMETER

20A, $3\frac{1}{2}$ digit frequency counter multimeter with capacitance meter and transistor tester.

This spectacular, rugged and compact DMM has a bright yellow high impact plastic case. It features a frequency counter (to 200kHz), diode and transistor test, continuity (with buzzer), capacitance meter, up to 20 amp current measurement and comprehensive AC/DC voltage, current and resistance ranges.

CHECK THESE FEATURES....
- Push-button ON/OFF switch
- Audible continuity test
- Single function, 30 position easy to use rotary switch for FUNCTION and RANGE selection
- Transistor test
- Diode test
- Quality probes
- $\frac{1}{2}$" High contrast LCD
- Full overload protection
- 20 Amp
- Built in tilting bail
- Capacitance meter
- Instruction manual

Q91550 .... Normally $165
Special, only $129

MINIATURE HOBBY VICE

- Lever operated suction grip base for instant mounting and portability
- Mounts on smooth non-porous surfaces.
- Ideal for holding components, and other small/light objects

Cat. T12458 ... **only $6.45**

CAR ANTENNA BOOSTER

- In-line installation
- 12V boosts 100%

Cat. A12073 .... **$7.95**

SOLDER ROLLS

Absolutely top quality, unlike our opposition's!
60/40 Resin cored

Cat.No.	Description	Price
T31000	.71mm 250gm	$8.95
T31002	.71mm 500gm	$15.95
T31010	.91mm 250gm	$7.95
T31012	.91mm 500gm	$14.95
T31020	1.6mm 250gm	$7.50
T31022	1.6mm 500gm	$13.95
T31030	.71mm 1 metre	$1.50
T31032	.91mm 1 metre	$1.25
T31034	1.6mm 1 metre	$1.00

SPECTROL MULTIDIALS

MODEL 15-1-11
Number of turns: 10
Minor Scale Division: 1 500 turn
Shaft Bore: 6.35mm ($\frac{1}{4}$")
Finish: Satin Chrome
Body Size: 25.4 x 44.45mm (1 x $1\frac{3}{4}$")
Depth: 25.4mm (1")
Weight: 45.4g (1.6oz.)
Cat.R14405 .... $45.95
SPECIAL, $35.95

MODEL 16-1-11
Number of turns: 15
Minor Scale Division: 1 50 turn
Shaft Bore: 6.35mm ($\frac{1}{4}$")
Finish: Clear Anodize
Body Size: 22.2mm diameter (.875")
Depth: 22.2mm (.875")
Weight: 19.8g (0.7oz.)
Cat.R14400 .... $26.95
SPECIAL, $21.50

MODEL 21-1-11
Number of turns: 15
Minor Scale Division: 1 100 turn
Shaft Bore: 6.35mm ($\frac{1}{4}$")
Finish: Satin Chrome
Body Size: 46.04mm diameter (1.812")
Depth: 25.4mm (1")
Weight: 85 g (3oz.)
Cat.R14410 .... $46.95
SPECIAL, $37.50

SPECIALS

METEX 4500H MULTIMETER

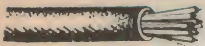
10A, $4\frac{1}{2}$ digit multimeter with digital hold, transistor tester and audible continuity tester.

The Metex 4500H is perfect for the technician, engineer or enthusiast who requires the higher accuracy of a $4\frac{1}{2}$ digit multimeter. This meter is exceptionally accurate, (just look at the specifications), and yet, still retains an exceptionally low price!

The Metex 4500H features digital hold which is normally only found on very expensive multimeters. This enables you take a reading and hold that reading on display even after you have removed the probes, simply by pressing the hold button.

CHECK THESE FEATURES...
- Readout hold
- Transistor Tester
- $4\frac{1}{2}$ digit x $\frac{1}{2}$"(H) LCD
- Audible continuity tester
- Push-button ON/OFF switch
- Quality set of probes
- Single function, 30 position easy to use rotary switch for FUNCTION and RANGE selection
- Built in tilting bail
- Instruction manual
- Full overload protection
- hFE test
- Battery and Spare fuse
- Diode Tester
- Vinyl case

Q91560 .... Normally $175
Special, only $159



COMPUTER CABLE

CIC6 6 conductor computer interface cable. Colour coded with braided shield (to IE422 specifications). Copper conductor 6 x 7/0.16mm.
1-9 metres **$1.90/m** — 10+ metres **$1.70/m**

CIC9.100 9 conductor computer interface cable. Colour coded with mylar shielding. 9 x 7/0.16mm.
1-9 metres **$2.50/m** — 10+ metres **$1.95/m**

CIC12 12 conductor computer interface cable. Colour coded with mylar shielding. 12 x 7/0.16mm.
1-9 metres **$2.70/m** — 10+ metres **$2.50/m**

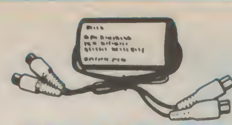
CIC16 16 conductor computer interface cable. Colour coded with mylar shielding. 16 x 7/0.16mm.
1-9 metres **$3.90/m** — 10+ metres **$3.40/m**

CIC25 25 conductor computer interface cable. Colour coded with mylar shielding. 25 x 7/0.16mm.
1-9 metres **$4.90/m** — 10+ metres **$4.40/m**

FLUORESCENT WORK & EMERGENCY LIGHT

- Suits cars, boating, caravan, camping etc.
- Shatterproof, glare free
- Cigarette lighter plug and alligator clips
- 12V DC, 8 watt, transistorised

Cat. A15052 .... **$25.95**



RCA TO RCA ISOLATION TRANSFORMER

- 15A high quality noise suppressor isolation transformer
- Designed to eliminate noise in the audio line
- Does not affect the audio signal
- Simply fits inline between car stereo and the separate power amplifier

M10038 .... **$15.95**

STEREO WIRELESS TRANSMITTER

This unit was developed to allow portable compact disc players to be used in cars by transmitting the headphone output signal directly in to your stereo FM car radio. It will also transmit any mono/stereo signal from any headphone output to any FM receiver

SPECIFICATIONS:
- Input 3·5mm stereo phone plug Impedance 32 ohm.
- Mono/stereo switch has plug mounting clip
- FM Transmission approx 90·35MHz (Tuneable 89-91MHz)
- Range 15 metres. (below 15mV/m at 100 metres)
- Power 1·5V AAA size batteries (100 hours continuous use)
- Size 72 x 38 x 21mm

A16100 .... **$69.95**

BARGAINS

AUTOMATIC CABLE STRIPPER

- Strips cable with diameter of 1 1·6 2 2·6 3·2mm
- Fully automatic action. Squeeze grip will simulataneously strip and eject insulation
- Length 180mm (7")

T11532 .... **$19.95**

RELAYS

	1-9	10+	100+
S.P.D.T 3A connectors S14060	**$1.50**	**$1.30**	**$1.10**
D.P.D.T 3A connectors S14061	**$1.95**	**$1.75**	**$1.30**
S.P.D.T 12V Coil 10A 240V S14114	**$7.95**	**$7.50**	**$6.95**

10W HORN SPEAKERS

White durable plastic. 8 ohms
Cat. C12010 — Normally $11.95
1-9 **$7.95** — 10+ **$6.95**

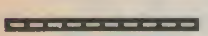
NEW COLOUR KNOBS!

Standard metric fluted shaft with black dot marker and available in six different colours!
Dimensions: 17·2mm high, 12·8mm top diameter, 17mm bottom diameter

Cat.No.	Colour	1-9	10+
H10070	Black	$0.75	$0.65
H10071	Blue	$0.75	$0.65
H10072	Green	$0.75	$0.65
H10073	Grey	$0.75	$0.65
H10074	Red	$0.75	$0.65
H10075	Yellow	$0.75	$0.65

TEXTOOL SOCKETS

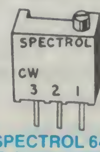
P17016 16 pin	**$14.95**
P17024 24 pin	**$18.50**
P17028 28 pin	**$24.95**
P17040 40 pin	**$29.50**



HIGH INTENSITY RED LED BAR GRAPH

Dimensions:
Overall: 63mm across. 5mm high
LEDs: 10 x 5mm x 1mm

Cat.No	1-9	10+
Z10180	**$2.95**	**$2.75**



SPECTROL 64Y MULTI TURN TRIMPOTS

Cat.No.	Description	1-9	10+
R14700	10R	$3.50	$3.20
R14710	20R	$3.50	$3.20
R14720	50R	$3.50	$3.20
R14730	100R	$3.50	$3.20
R14740	200R	$3.50	$3.20
R14750	500R	$3.50	$3.20
R14760	1K	$3.50	$3.20
R14770	2K	$3.50	$3.20
R14780	5K	$3.50	$3.20
R14790	10K	$3.50	$3.20
R14800	20K	$3.50	$3.20
R14810	50K	$3.50	$3.20
R14820	100K	$3.50	$3.20
R14830	200K	$3.50	$3.20
R14840	500K	$3.50	$3.20
R14850	1M	$3.50	$3.20

RANGE

ECONOMY TRANSFORMERS

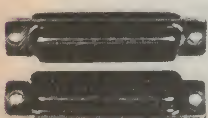
	1-9	10+
2155 240V 6-15V 1A Cat M12155	$9.95	$8.95
2156 240V 6-15V 2A Cat M12156	$14.95	$13.95
2840 240V 9V CT Cat M12840	$5.95	$4.95
2851 240V 12-6V CT 150mA Cat M12851	$5.95	$5.50
2860 240V 15V CT 250mA Cat M12860	$5.95	$4.95
6672 240V 15-30V 1A tapped Cat M16672	$14.95	$13.95

10 TURN WIRE WOUND POTENTIOMETER

Spectrol Model 534
1/4" shaft.
Equiv (Bourns 3540S, Beckman 7256)
Dials to suit 16-1-11, 18-1-11 21-1-11

R14050	50R	R14100	5K
R14055	100R	R14110	10K
R14060	200R	R14120	20K
R14070	500R	R14130	50K
R14080	1K	R14140	100K
R14090	2K		

1-9 **$9.95** — 10+ **$9.50**



DB25 CONNECTOR SPECIALS!

TYPE	1-9	10+	100+
9P	$0.70	$0.60	$0.50
9S	$0.70	$0.60	$0.50
9C	$0.60	$0.50	$0.40
15P	$0.70	$0.65	$0.60
15S	$0.70	$0.65	$0.60
15C	$0.70	$0.60	$0.50
25P	$0.70	$0.60	$0.50
25S	$0.75	$0.65	$0.60
25C	$0.70	$0.60	$0.50

DB 25 CRIMP SPECIALS!

Type	1-9	10+	100+
Female	**$2.95**	**$2.50**	**$1.95**
Male....	**$2.95**	**$2.50**	**$1.95**

NOW OPEN IN SYDNEY!

74 PARRAMATTA RD, STANMORE
PHONE (02) 519 3134

METEX 3800 MULTIMETER

This instrument is a compact, rugged, battery operated, hand held 3 1/2 digit multimeter for measuring DC and AC voltage, DC and AC current, Resistance and Diode, for testing Audible continuity and transistor hFE. The Dual-slope A-D Converter uses C-MOS technology for auto-zeroing, polarity selection and over-range indication. Full overload is provided. It is an ideal instrument for use in the field, laboratory, workshop, hobby and home applications.

Features...
- Push-button ON/OFF power switch
- Single 30 position easy to use rotary switch for FUNCTION and RANGE selection
- 1/2" high contrast LCD
- Automatic over-range indication with the "1" displayed
- Automatic polarity indication on DC ranges
- All ranges fully protected plus Automatic "ZERO" of all ranges without short circuit except 200 ohm Range which shows "000 or 001"
- High Surge Voltage protection 1.5 KV-3 KV
- Diode testing with 1 mA fixed current
- Audible Continuity Test
- Transistor hFE Test

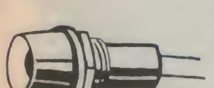
SPECIFICATIONS
Maximum Display: 1999 counts 3 1/2 digit type with automatic polarity indication
Indication Method: LCD display
Measuring Method: Dual-slope in A-D converter system
Over-range Indication: "1" Figure only in the display
Temperature Ranges: Operating 0-C to +40-C
Power Supply: one 9 volt battery (006P or FC-1 type of equivalent)

Cat Q91530 — **Normally $109**
SPECIAL $79

RECHARGEABLE 12V 1.2AH GELL BATTERY

Leakproof, long service life batteries ideal for security systems emergency lighting or as a computer backup power supply etc

Cat. S15029 — **Normally $19.95**
1-9 **$13.95** — 10+ **$12.95**



CHROME LED BEZELS

9mm hole, available 3 colours

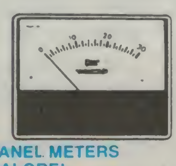
Cat.No.	Description	Price
S14030	Red	**$1.20**
S14032	Green	**$1.45**
S14034	Yellow	**$1.45**

JOINABLE PCB MOUNTING SCREW TERMINALS (GREY)

	1-9	10+
2 Way Cat P10520	**$0.50**	**$0.45**
3 Way Cat P10521	**$0.75**	**$0.65**

MINIATURE BUZZER

5-15V White or black.
Cat. C15062 — 1-9 **$2.50** — 10+ **$2.25**



PANEL METERS GALORE!

We have a great range of panel meters at great prices!

Cat.No.	Description	Price
Q10500	MU45 0-1mA	12 50
Q10502	MU45 50-0 50uA	12 50
Q10504	MU45 0-100uA	12 50
Q10510	MU45 0-5A	12 50
Q10518	MU45 0-1A	12 50
Q10520	MU45 0-1A	12 50
Q10525	MU45 0-20V	12 50
Q10530	MU52E 0-1A	14 50
Q10533	MU52E 0-5A	14 50
Q10535	MU45 VU PMetre	14 95
Q10538	MU65 0-50uA	16 95
Q10540	MU65 0-1mA	16 95
Q10550	MU65 0-100uA	16.95
Q10560	MU65 0-20V	16 95

DIECAST BOXES

Diecast boxes are excellent for RF shielding, and strength
Screws are provided with each box

H11451	100 x 50 x 25mm	$ 5.95
H11452	110 x 60 x 30mm	$ 6.50
H11453	120 x 65 x 40mm	$ 6.95
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Active matrix LCD displays

Slowly but surely, the cathode ray tube is being nudged out of its long-held position of leading graphics and picture display device. The latest contender is active-matrix LCD displays, where each pixel is switched by thin-film transistors fabricated on the display itself. Here's a report from the US on how this technology is developing.

by PASCAL ZACHARY

Big, bulky and power hungry, the cathode ray tube is out of place in an era of ever smaller electronic gadgets. It is also the subject of much controversy. Health experts are examining possible links between the CRT and a variety of disturbing problems, including miscarriages and loss of eyesight.

Meanwhile, scores of visionary designers are out to jettison the CRT for another reason: it stands in the way of creating wall-size televisions and personal computers that can be tucked under an arm.

But now researchers seem closer than ever to catching up to – and perhaps ultimately leapfrogging over – the durable CRT. Their weapon: a new technique called *active matrix*.

Today, active matrix is in its infancy; but "it is the future," says Joseph Castellano, a leading expert in the field and president of Stanford Resources, a San Jose research firm. "The other approaches just don't offer the performance."

Ultimately, active matrix will "result in a high-definition TV you can hang on the wall," says William Chandler, a partner in Bay Venture Group, a San Francisco venture capital firm. Active matrix, "If it is good enough, will create a major push to turn every personal computer into a lap-top," says Lee Watkins, an engineer at Grid Systems, which manufactures portable computers in Fremont, California.

Already, some of the biggest names in Japanese consumer electronics – including Sharp, Seiko, NEC and Hitachi are pouring an estimated $100 million a year into active matrix. And a handful of US firms are also pioneering in this field, including Alphasil of Fremont and General Electric.

While the outlook for active matrix is rosy, the technology must clear a major hurdle: cost, as active matrix is currently very expensive. Castellano estimates that 5″ diagonal active matrix displays can easily cost $600, or roughly five times the price of a 19″ colour television tube. However prices are expected to decline as production increases.

In the meantime, potential Japanese suppliers of active-matrix displays are straining to perfect the technology. In May, many of these firms demonstrated active-matrix displays at a Society of Information Displays conference in Anaheim, and Hitachi already sells in Japan a portable TV using a 5″ active matrix screen.

Apple may be first

Apple Computer of Cupertino is likely to become one of the first major US companies to build a critical product around active matrix. Industry sources believe that Apple's first lap-top computer, expected next year, will use an active matrix screen.

One problem facing active matrix is size. Initially, active matrix displays will be small – perhaps 5″ in diagonal width. But within a few years 12″ diagonal screens should be plentiful, according to Sol Sherr, a consultant in Old Chatham, NY, who recently completed a detailed study of the technology.

Currently, most lap-tops and hand-held televisions use standard liquid crystal displays. Before hitting upon active matrix, Japan Inc. adopted liquid crystal displays for its products. These displays have improved dramatically in recent

Active matrix in colour. Unfortunately our black and white reproduction doesn't show the effect, but this display is actually showing five colours.

years as manufacturers resort to a back layer of lighting to improve the picture. But active matrix offers far better performance than standard liquid crystal, although pricing will favour the latter for sometime yet.

Because the Japanese already dominate the CRT business, most large US firms aren't interested in fighting with Japan Inc. over the next generation of visual displays. The few US firms that have entered the market plan to peddle their wares to the Defence Department, which is willing to pay premium prices for displays it uses in airline cockpits and tanks.

Japan may win

Because of the differing strategies, it seems likely that the Japanese will come to dominate active matrix, which by 1993 may represent a $US1.4 billion annual business. The US appears destined to lose the fight with Japan.

"For US industry, there isn't a whole lot of hope," Castellano says. Nevertheless, Castellano and others think the United States may hold a wide technological lead in the field.

Alphasil, for instance, already sells black and white active matrix displays to a number of defence contractors and offers to fill custom orders for colour displays. Only a few Japanese companies are offering to sell US firms black and white displays and none is offering colour displays, says Henry Fung, vice president of engineering at San Jose based Yadem, which has designed numerous lap-top computers.

However despite an apparent US lead, the Japanese seem likely to dominate this budding field quickly.

"There is a great opportunity here for the US, but will we take advantage of it? The answer is probably no," says Castellano. "The Alphasils of this country don't have the production capabilities to meet the Japanese. They don't have the financial punch it takes."

Many observers agree that active matrix is likely to prove crucial to future products, but they say that US investors aren't willing to heavily support efforts in an area the Japanese fiercely seek to control. And without capital, US firms such as Alphasil have been forced to set their sights on catering to the specialised needs of the military, which wants to use active matrix displays in tanks, airplane cockpits and ships.

"Alphasil doesn't have a choice. If it tries to enter the commodity market, even though it has the technology, the Japanese will counter with a strategy aimed at blowing everyone out of the water", says John Maio, a director of business development at Honeywell's Defence Avionics Systems Division in Aluquerque, New Mexico. Honeywell owns about 20% of Alphasil, and has exclusive worldwide rights to the defence and aerospace market.

The quality, size and readability of the active matrix screen is making it sought after by the US defence industry.

Yet Richard Flasck, Alphasil's president, bristles at the notion that the Japanese are waiting in the wings to deliver a killer blow. "The Japanese have waged a very good scare campaign in this area," he says. "The nett result is that it really eliminates the possibility of US firms obtaining meaningful funding for this technology."

At present it looks as though the best in US active-matrix technology may never find a place in civilian products.

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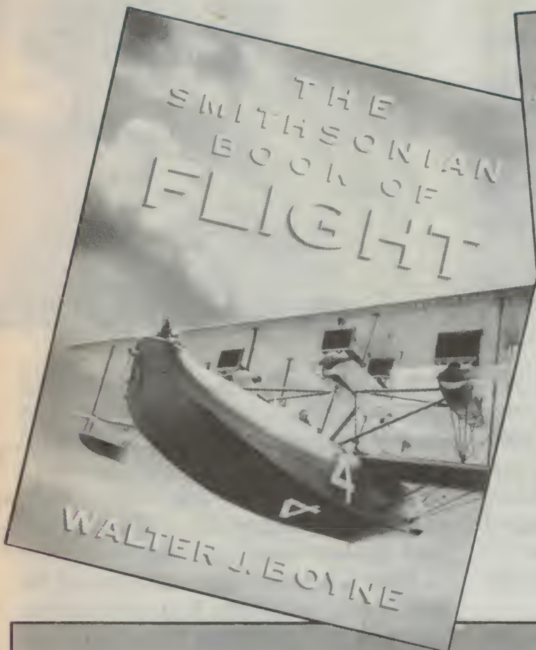

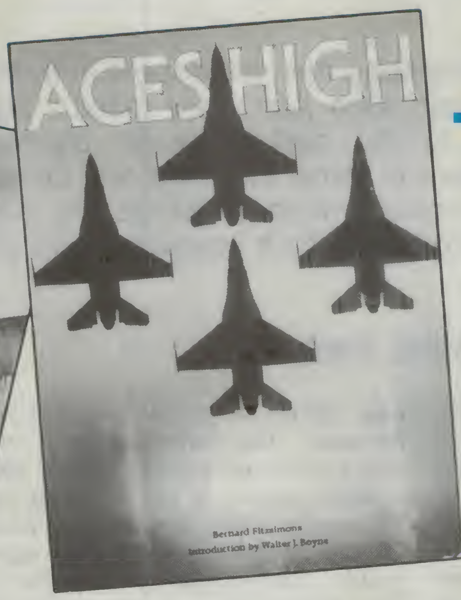

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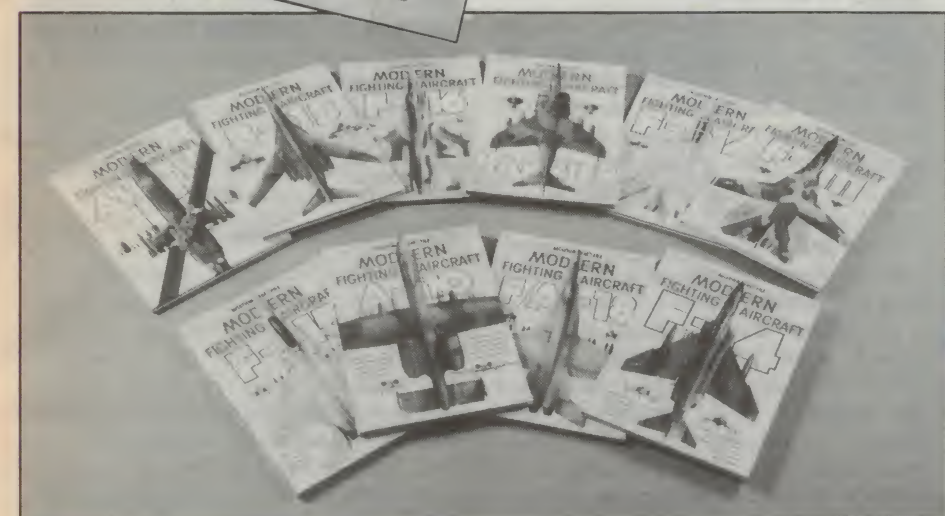

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How they work, how to fix them:

Electronic phones

So the beaut little second telephone that you bought from the local supermarket at a bargain price just a few months ago has given up the ghost. At the cost of repair charges nowadays you'll probably have to throw the thing out. Or will you? With a bit of an idea about how these things tick, and some spare time, you could probably fix it yourself. Read on, your troubles may be over.

by CHRIS KING

To begin with, let's look at the basic functional sections a telephone needs, in order to do what it does. These are the speech circuitry, signalling circuitry and the call indicator or ringer.

The speech circuitry translates our voice into electrical signals which are applied to the phone line, and produces sounds in the earpiece derived from signals received from the 'other end' via the same line. In its simplest form the speech circuit requires a microphone and a receiver or earpiece.

Until a few years ago, common telephones employed a carbon microphone. This consists of a chamber of carbon granules, which varies its resistance in response to sound waves. The varying resistance modulated a direct current passing through the granules.

Carbon microphones are relatively large and do not provide consistent performance. The carbon granules also tend to settle and become 'packed' after a while, causing a loss in sensitivity. This is why tapping the telephone handset can sometimes improve its signal quality. The frequency response of these microphones is peaky and is also subject to variations.

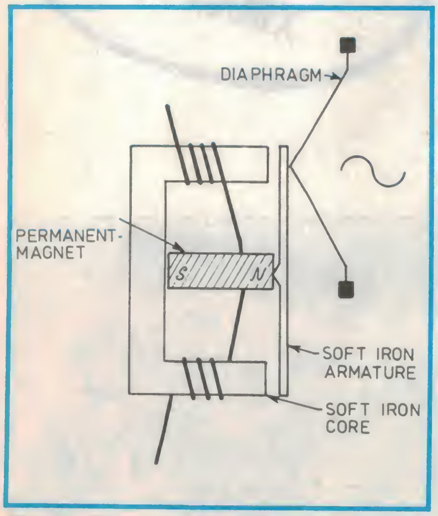

Fig.1: The basic principle of the rocking-armature receiver, as used in non-electronic phones.

Given their imperfections, it is not difficult to understand why they are now rarely used. The main advantage of the carbon microphone is its ability to develop a signal that is large enough for application to the phone line, without the need for further amplification; that is, it's quite *sensitive*.

Early telephones employed a simple receiver made up of a thin, compliant, iron diaphragm mounted in the field of a permanent magnet which biased it. Speech signal currents applied through a coil wound on the magnet modulated the magnet's field, causing the diaphragm to vibrate. Because a permanent magnet has a high reluctance, i.e., it tends to impede changes in its magnetism, this type of receiver was barely sensitive enough for the job.

A similar but improved receiver is the *rocking armature* type, shown in Fig.1. Here speech currents modulate the strength of two magnetic paths through the soft-iron armature and core, in a complimentary manner, causing it to rock. This action is coupled to the diaphragm. As the armature is able to apply bi-directional force on the diaphragm, no biasing field is necessary. Although the rocking armature receiver is a bit more complex, it is more sensitive and can be designed to have better acoustic properties.

The telephone line, which simultaneously conducts the signals from both parties in a telephone conversation, is just a single pair of wires. If the speech circuitry in each telephone were nothing more than a microphone and a receiver, each person would hear their own voice in their receiver louder than that of the other, as it would not have suffered the losses of the telephone line. The existence of our voice in our own earpiece is called *sidetone*.

Fortunately, it is possible to significantly reduce sidetone with a clever balancing circuit called the anti-sidetone circuit, or sometimes the *hybrid*.

Reducing sidetone

Fig.2 shows a simplified diagram of a telephone's anti-sidetone speech circuit when transmitting speech signals. Speech currents from the microphone split into two paths, I_B and I_L, flowing in opposite directions through the transformer primaries. By choosing the correct relationship between the ratio of the telephone line impedance (Z_L) and the balance impedance (Z_B) and the

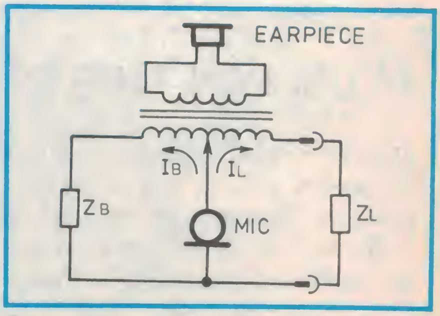

Fig.2: The anti-sidetone circuit of a conventional phone, in simplified form.

ratio of the turns in the two primaries, the two opposing speech currents will produce no resultant signal in the secondary winding.

In a practical telephone the anti-sidetone transformer is wound as an autotransformer and the turns ratio and balancing impedance are chosen such that an adequate proportion of the speech current is passed to the phone line.

Because the impedance of the phone line is somewhat unpredictable, total sidetone cancellation is not practical. Fortunately it also unnecessary, because the phone sounds more natural when we hear our voice at about the same level as we do in normal conversation without the handset.

Dialling circuitry

To get the telephone exchange equipment to connect us to another phone, it has to know that we want to initiate a call and also the address – i.e., the phone number – of the telephone we're calling. This information is generated by the phone's *signalling* circuitry.

When the telephone handset is 'hung-up' or 'on-hook', the telephone draws little if any DC current and the full open-circuit exchange voltage of about 50 volts is present across the phone line terminals. Lifting the handset allows a switch, known as a gravity switch, to connect the phone's speech circuits to the line. Equipment at the the exchange senses the current drawn by the phone, and allocates the necessary circuits to decode address signals from the phone and then make the connection through to the phone being called.

The majority of telephones in use in Australia employ what is known variously as pulse, loop-disconnect or *decadic* signalling to transfer address information to the exchange. With this signalling method, the DC loop established when the phone is taken 'off-hook' is sequentially opened for about 67ms (milliseconds) and then closed again for about 33ms before the next 67ms open period.

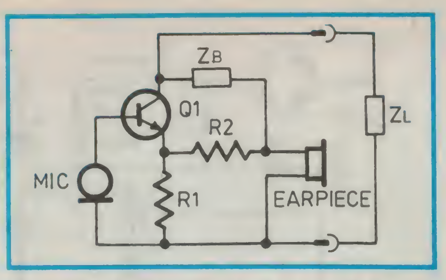

Fig.3 (above): The basic sidetone nulling circuit used in many electronic phones.

The number of open or 'break' periods represents the digit being dialled. For example, if the digit '5' is dialled, the dialling circuitry in the phone open-circuits the phone line for five 67ms periods, each one separated by a 33ms closed period.

To separate one digit from the next, the pulse train for each digit is followed by a closed circuit or 'make' period of at least 800ms; this is referred to as the *inter-digital pause* or IDP.

Decadic signalling is easily achieved by the electro-mechanical rotary dial used in most older telephones.

To activate the incoming call indicator or 'ringer' in our phone, the exchange applies an AC signal of about 75 volts to the line. This signal is on for about 200ms then off for about 400ms, then on for 200ms and off for about 2s, before repeating again. This pattern, or *cadence*, results in the familiar 'bring-bring' ringing sound.

When the exchange equipment senses that the phone has been answered, ring current is removed from the line and the connection to the calling phone is made.

The ringer in the phone must monitor the line when the phone is 'on-hook'

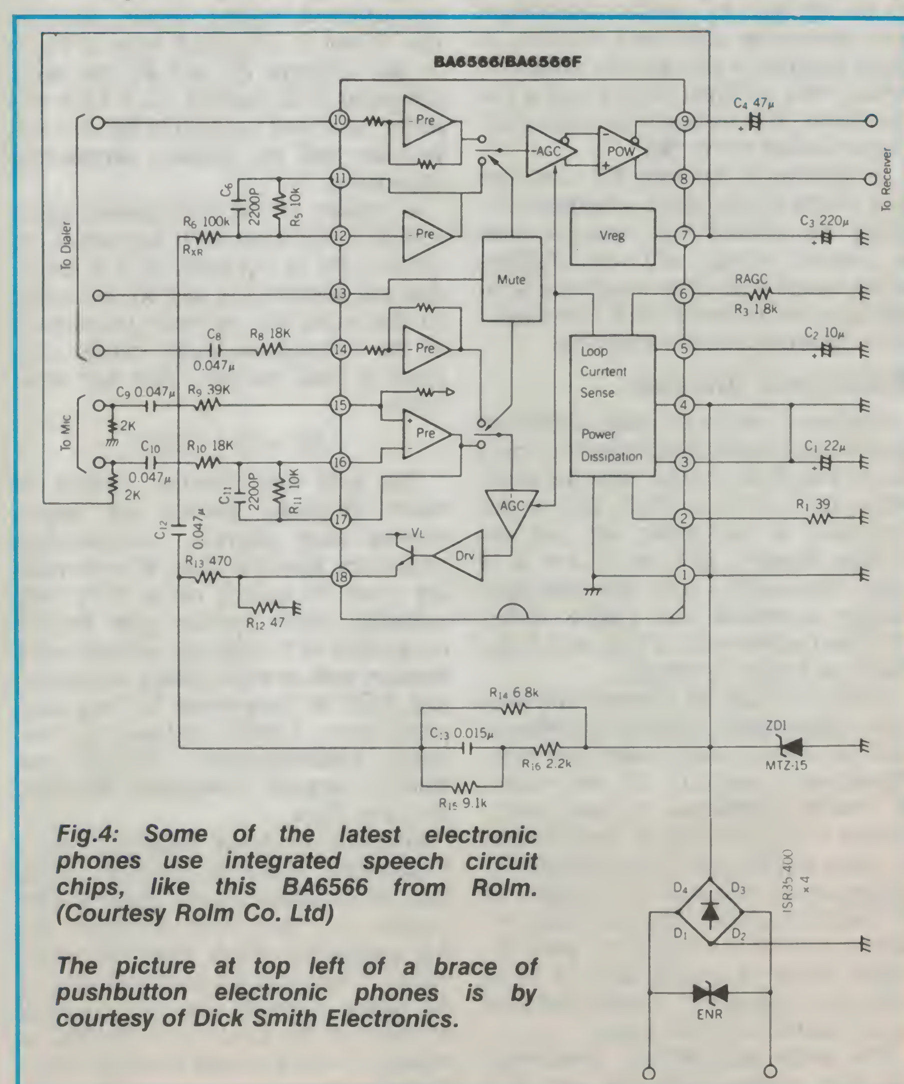

Fig.4: Some of the latest electronic phones use integrated speech circuit chips, like this BA6566 from Rolm. (Courtesy Rolm Co. Ltd)

The picture at top left of a brace of pushbutton electronic phones is by courtesy of Dick Smith Electronics.

and must draw no DC current. In phones for use in Australia, the ringer is always coupled to the line via a high-voltage capacitor of 1-1.5uF. Besides blocking DC, the capacitor provides a standardised 'on-hook' characteristic for line testing purposes.

In older telephones, the ringer itself is an electro-mechanical bell operating on the same principle as the rocking armature receiver already described.

We have now looked at the main functional blocks of a basic telephone. All of the functions can be implemented using rugged, tried and proven passive devices. Telephones constructed with not much more than the above, while having only basic features, have provided us with a reliable and easy to use means of communication for over half a century.

However developments in semiconductor technology have allowed many of the components in the basic telephone to be replaced by smaller, lightweight and inexpensive electronic circuitry. A good example is the modern dialler IC which, with a simple keypad and a few transistors, has replaced the bulky electromechanical rotary dial.

In addition to lowering the cost, size and weight of the phone, electronic circuitry has allowed extra features, such as number storage and tone dialling, which would have been totally impractical using electro-mechanical technology, to be incorporated into telephone.

Electronic phones

Originally one of the main difficulties to overcome in the development of electronic telephone circuitry was the available supply voltage which, due to the resistance of the phone line and exchange circuitry, may be as low as 5 volts. Fortunately, with low saturation voltage transistors and CMOS dialler ICs that can run with as little as 2 volts, this is no longer a problem.

With the ability to electronically amplify signals, high-sensitivity transducers such as carbon microphones and rocking-armature receivers are not needed in modern telephones. Carbon microphones have given way to small dynamic, piezo-electric and electret condenser microphones, followed by transistor or IC amplifier circuits. Similarly bulky receivers have been replaced by small dynamic inserts or loudspeakers of 50 to 150 ohms impedance, usually preceded by a transistor amplifier stage.

The bulky anti-sidetone transformer has been eliminated by the use of a transistorised nulling circuit, such as that shown in simplified form in Fig.3. In this diagram Z_B and R2 are large compared to Z_L and R1. Z_L is Q1's collector load, and represents the line impedance and the phone's terminating impedance.

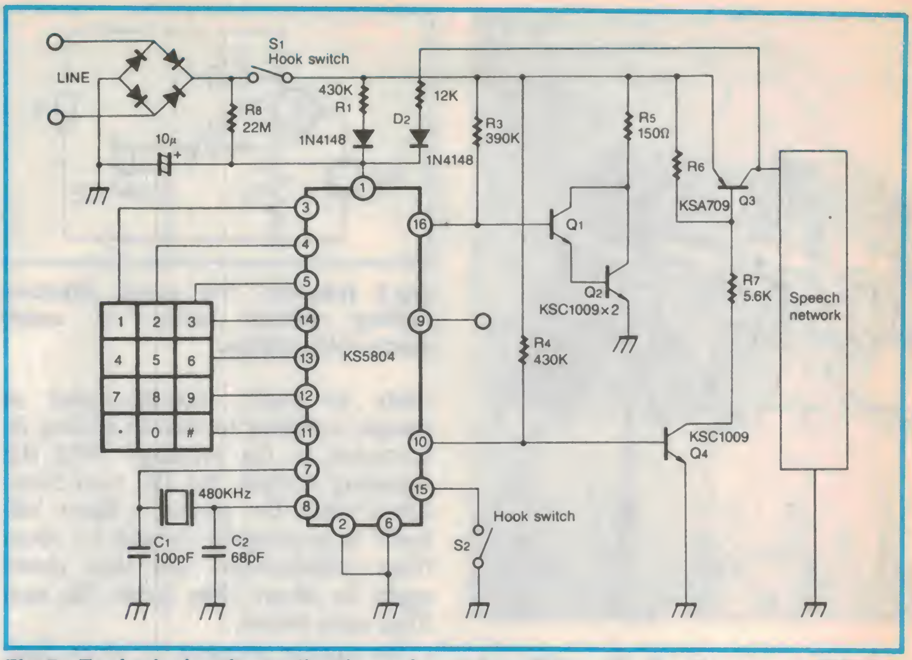

Fig.5: Typical circuit application of a pulse dialler IC, the Samsung KS5804. Pin 16 switches Q1 and Q2 on and off, producing the dialling pulses via R5. (Courtesy Samsung Semiconductor)

A replica of the microphone signal applied to the base of Q1 appears at the emitter, but at the collector it is amplified and inverted. Z_B and R2 are scaled so that equal but opposite proportions of the microphone signal cancel each other at their junction. This will occur when

$$Z_B = Z_L \times R2/R1$$

The gain and sidetone circuits in many electronic phones are implemented using discrete, low-saturation transistors. However there is an increasing array of speech circuit IC's now available, which operate quite happily on as little as 2 volts and provide extra features such as tone dialling interfacing and AGC to compensate for long telephone lines. Typical examples are National Semiconductor's TP5700 and Rohm's recently announced BA6566, shown in Fig.4.

Ringers in electronic telephones use a loudspeaker or ceramic sounder driven from an oscillator circuit. Some special purpose ICs have been developed for this application, which allow the phone owner to vary the loudness and tone of the ringer. Probably the most common of these is the KA2410 or SL8204, a variant of which is used in recent Telecom telephones.

In this chip a slow oscillator operating at about 10Hz sweeps a tone oscillator around 600Hz, producing a pleasant ringing sound. This IC is produced, with varying part number prefixes, by a number of manufacturers including Plessey, SGS, Samsung and Mitel. Like most ringer circuits, the chip is normally powered by rectifying the AC ring signal from the exchange.

Dialler chips

The first section of the telephone to be implemented in IC form was the loop-disconnect (decadic) dialler. An enormous range of these ICs has become available, all providing similar basic functions. Some provide extra features such as ten (or more) number storage and the ability to select different dial rates and break:make ratios to suit varying national standards. Table 1 lists some of the more common types.

Fig.5 shows an application of a typical pulse dialler IC, the Samsung KS5804. Numbers are entered via a 7-key keypad, which is scanned as a 3 by 4 matrix by the IC. As a timebase, the chip uses a 480kHz ceramic resonator. In general, pulse diallers use either this timebase or a low frequency (2-20kHz) RC oscillator.

To conserve power, the oscillator only runs whens necessary – i.e., immediately following the detection of a key press, and during transmission of dialling pulses.

Pin 10 is an output used to mute the speech circuitry during dialling, so as to

prevent loud dialling clicks from being heard in the earpiece. Pin 16 provides the actual dial pulses and is used, in this case, to connect and disconnect R5 – which is the load on the line during 'make' periods. In many phones, the speech circuitry itself is used as the dialling load.

Pin 9 of this IC selects the break:-make ratio, at either 60:40 or 67:33.

Many pulse dialler ICs have provision to select different dialling pulse rates and inter-digital-pause periods. For Australian conditions, the dialler should be configured as follows:

Dial rate	10 pulses per second
Break:make	67:33
IDP	800ms or more

Tone dialling

A more modern method of sending dialling information, which has only become practical with the advent of IC technology, is dual-tone multi-frequency (DTMF) encoding. Here instead of opening and closing the DC loop, standardised pairs of carefully selected audio tones are transmitted along the phone line in the same manner as speech signals. Decoding equipment at the exchange identifies these special tones codes and initiates the appropriate call routing action.

The DTMF tones are shown in Table 2. There are 16 different combinations, each made up of one of the low group of tones with one of the high group. Ten of these combinations are used to represent the digits 0 to 9, leaving the other six available for special uses.

Once a connection has been made, the same tones can then be used for remote control of equipment, such as telephone answering systems, or for entry of data into a remote banking system for example.

DTMF dialling is faster than pulse dialling. For example, to dial the 6-digit number '565656', a decadic dialler would take over 8 seconds, whereas the DTMF encoded number could be transferred in just 1 second. However, few DTMF dialler ICs are equipped with last-number redial or multi-number memory features. Also, because most subscriber lines in Australia are configured for pulse dialling, DTMF dialling is not common here in simpler telephones.

The nitty gritty

Armed with this understanding of the basic sections of a telephone, let's now take a look at how they all fit together in Fig.6, the actual circuit of a typical modern electronic phone.

The 2-wire phone line enters at the top left of the circuit and with the hookswitch, SW1, in the on-hook position, as shown, the line is connected to the ringer circuit in the bottom-left corner.

The ringer comprises a 2-transistor multivibrator configuration, driving a ceramic piezo element, PZ1. Capacitor C1 isolates the line's DC from the ringer so that it only operates from the high-voltage, AC ring signal.

In this particular circuit, the ringer oscillator only operates during positive half-cycles of the ring signal. Commonly, the ringer oscillator is powered via a full-wave rectifier.

Zener diode D14 sets a threshold voltage for the ringer to prevent it from 'tinkling' in response to dialling transients produced by parallel connected phones. The ringer switch shorts out the oscillator in the 'off' position, preserving the standardised 1uF on-hook line termination.

Resistor R1, which bypasses the hook switch in the on-hook position, provides the minute current needed to keep the dialler IC's last-number-redial memory alive.

When the phone is picked up, the hookswitch contacts changeover, connecting the dialling and speech circuits and in this case disconnecting the ringer

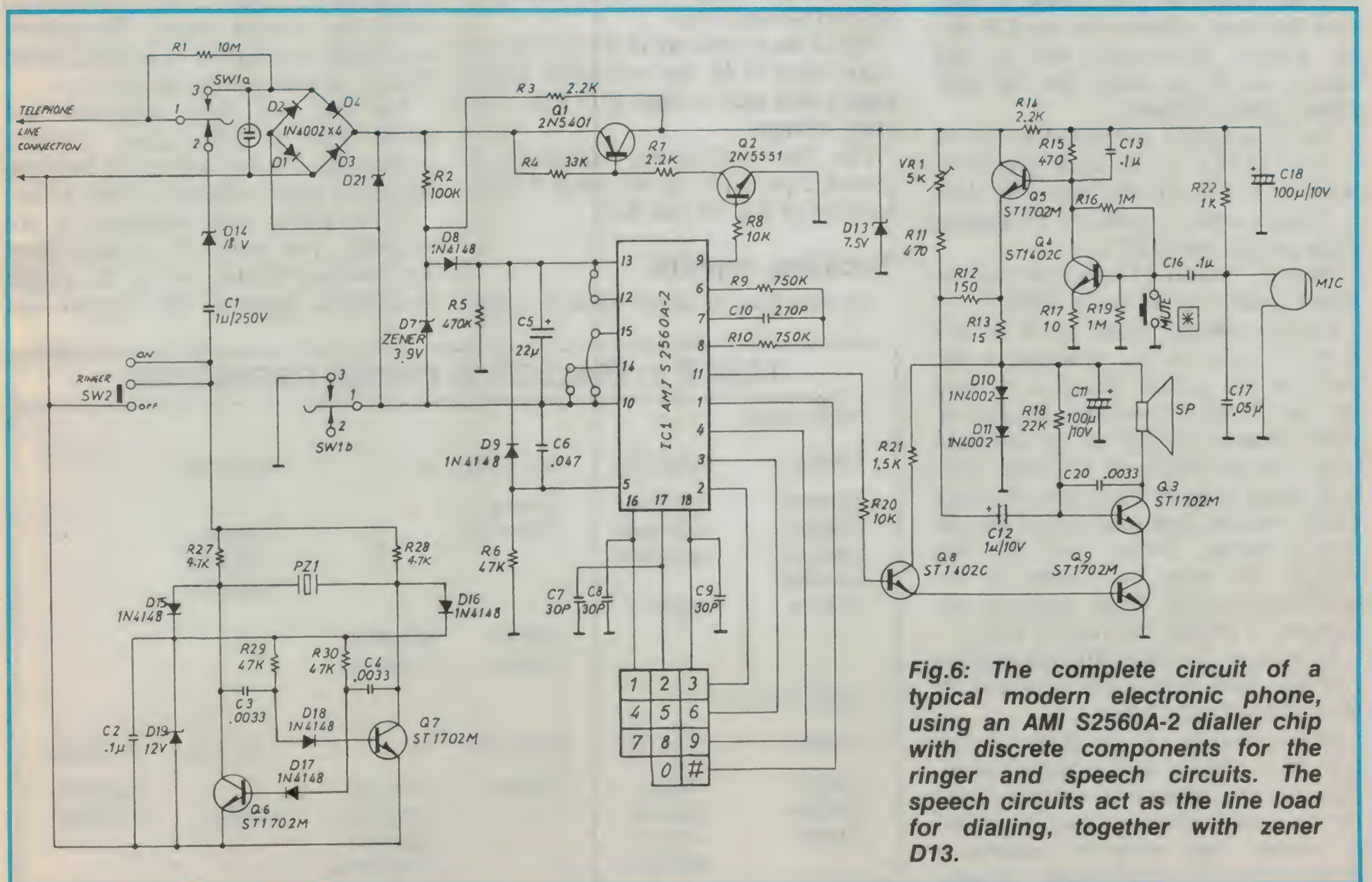

Fig.6: The complete circuit of a typical modern electronic phone, using an AMI S2560A-2 dialler chip with discrete components for the ringer and speech circuits. The speech circuits act as the line load for dialling, together with zener D13.

Electronic phones

circuit. In many phones the ringer stays across the circuit in the off-hook state.

As the line polarity is unknown, a full wave bridge, D1-D4, is needed to correctly route the line current to the polarity-sensitive speech and dialling circuitry.

In the off-hook state, the dialler IC is powered via R2 and, except during dialling break periods, R3. D7 and D8 limit the supply voltage to the IC to just over 3 volts.

When the contacts of SW1b close, the 'ground' side of the 'phone circuitry is connected to the negative output of the supply, pulling pin 5 of dialler IC1 low via R6. This indicates to the IC that the phone is on-line. The IC assumes an operational condition, sourcing current from pins 9 and 11 to activate the speech circuitry at the right of the diagram.

Pins 16, 17 and 18, and pins 1, 2, 3 and 4 are the keyboard column and row inputs respectively. The IC detects the connection of a row with a column and generates the appropriate dialling pulse train. These pins are referred to as 'inputs' on this particular IC because there are 2 other methods of interfacing to the chip where the pins are true inputs. The connection method shown, is however the most common one used in simple phones. Incidentally, the [#] key causes the IC to redial the last telephone number entered.

The components connected to pins 6, 7 and 8 of IC1 set the clock frequency, which is 2.4kHz for this chip. The clock is divided down to provide the dialling pulse periods and IDP time.

Pins 12, 14 and 15 select the various timing options, as shown in Table 3.

Current sourced from pin 9 of IC1 turns Q2 and Q1 on, providing a DC path via the speech circuitry, to loop the line. These 2 transistors, common to many phones, are high-voltage switching types able to withstand 150 volts. This high rating is needed to cope with back EMF from the feed inductors at the exchange during dialling, and the ring voltage that may be present as the hookswitch closes. These transients are clamped to around 110 volts by D21.

In addition to connecting the speech circuitry, these transistors are pulsed off to transmit dialling pulses.

During dialling, pin 11 holds Q8 and Q9 off to disable the receiver circuit. Because this reduces the current drawn by the speech circuitry, D13 is needed to ensure that adequate current is drawn during the dial 'make' periods.

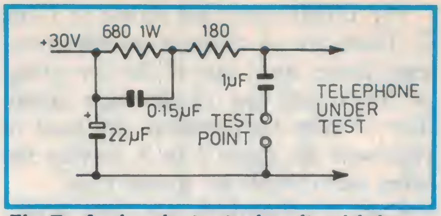

Fig.7: A simple test circuit which can be used for troubleshooting.

With the receiver circuitry enabled, D13 is effectively out of the circuit as the voltage across it will have dropped below its knee point.

In common with most electronic phones, a common 2-terminal electret microphone is used. These devices appear electrically as an open-drain FET. R22 is the microphone's 'drain' load.

The microphone signal is amplified by Q4 and applied to the line via the collector of Q5. This transistor is configured in the anti-sidetone circuit discussed before. The sidetone balance is adjusted by VR1. Note that the lower end of R13, being heavily bypassed by C11, is an AC ground.

Received signals, and attenuated transmit signals, are coupled from the junction of R11 and R12 to Q3, the receiver amplifier. Q3 drives the earpiece, a small 150 ohm speaker, in a class A configuration. The receive circuit is powered from just 1.5 volts developed across D10 and D11.

All of the transistors in the speech circuitry need to be low saturation types, having high gain at these very low operating voltages.

The line terminating impedance is provided primarily by the parallel combination of R3, R7 and R14.

Tackling repairs

So now that we know what to expect inside the little beast, what else might be handy before we attack it?

To make things easier, try to get as much information about your particular phone as possible. The telephone supplier should let you have a copy of the circuit, if they have one. Data about the dialler IC could be invaluable. With a bit of luck, your dialler IC, or an equivalent, might be detailed in one of the more readily available data manuals, such as National Semiconductor's linear series. If all else fails, a bit of intuitive circuit tracing might see you through.

You won't want to work on the phone while it is connected to the telephone line. Besides the possibility of being bitten by line transients, you can expect a hefty financial 'bite' from Telecom if you cause any interference or damage to its exchange equipment.

The test circuit shown in Fig.7 can be cobbled together in a plastic case and powered from an existing DC supply. Note that neither side of the supply should be earthed, as this would prevent you from moving signal generator and CRO earth leads around the phone circuits.

The test point can be connected to a CRO to monitor dialling pulses and transmitted speech signals. Alternatively it can be fed from an AF generator to check the receiver circuit. The generator should be adjusted to produce about 250mV of signal across the phone.

The last, and most important tool you'll need is some good, intuitive guesswork. Try to analyse the fault exhibited to isolate where it's likely to be.

If the dialler isn't operating, or not properly, you might for example start by checking whether any of the fragile connections between the keypad and

TABLE 1: DIALLER IC CROSS REFERENCE

Pulse diallers

SHARP	MOSTEK	NATSEMI	G.I.	SAMSUNG
LR40981	MK50981	TP50981		
LR40982	MK50982	TP50982		KS5804
LR40992	MK50992			KS5805A
LR40993				KS5805B
LR4173	MK5173			
		TP9151	AY5-9151	
		TP9152	AY5-9152	

DTMF diallers

SHARP	MOSTEK	NATSEMI	T.I.	SAMSUNG	PLESSEY
LR4087	MK5087	TP5087	TCM5087		MV5087
LR4089	MK5089		TCM5089	KS5808	MV5089
LR4091	MK5091		TCM5091		
	MK5092		TCM5092		

TABLE 3: AMI S2560A-2 DIALLER PIN PROGRAMMING

Pin #	Function	Low-Vss	High-Vdd
12	Break/Make Ratio	67:33	60:40
14	Dialling Pulse Rate	10 pps	20 pps
15	IDP length	800ms	400ms

Above: The mode control pin programming for the AMI dialler chip used in Fig.6. Right: The tone pair combinations used for DTMF dialling. The table at the bottom of the facing page shows a cross reference between many of the dialler chips currently available.

TABLE 2: DTMF TONE COMBINATIONS

		High group tones (Hz)			
		1209	1336	1477	1633
Low Group	697	(1)	(2)	(3)	(A)
	770	(4)	(5)	(6)	(B)
	852	(7)	(8)	(9)	(C)
	941	(★)	(0)	(#)	(D)

This table shows the relationship between keypad digits and DTMF tone pairs. Pressing the (5) key, for example, produces a 770Hz tone along with a 1336Hz tone.

the IC has parted company. Check to see if the chip shows any signs of activity, such as the oscillator running, as keys are pressed. If all seems in order, you could trace the path of the dial pulses through the switching transistors.

Always check to see whether the various circuits seem to have the right supply voltages. Inspect any flexible connections between switches, microphones etc. Generally speaking, no circuit will give the right output if its not provided with the right input.

If you do isolate a faulty component, your next problem is to locate a suitable replacement. Most parts suppliers have suitable replacements for the high voltage switching transistors, and common resistors, capacitors and diodes should present no problem. As replacements for speech circuit transistors, BC337s will often suffice, especially if higher gain types can be selected.

Probably the most difficult component to replace will be the dialler IC. The telephone supplier may be able to sell you a spare or, with a bit of luck, one of the semiconductor distributors or specialist parts importers may carry the part you need.

Although there is always the chance of disappointment when attempting to repair economy 'throw-away' equipment such as this, just as often your efforts could result in many more years of trouble free performance. At worst, there is still the garbage bin option, but at least you will have gained a bit more knowledge and experience in the process.

Knowing what a phone's internal circuitry has to do, and at least the broad way in which it's done, is usually more than half the battle. So hopefully the above information will get you off to a good start.

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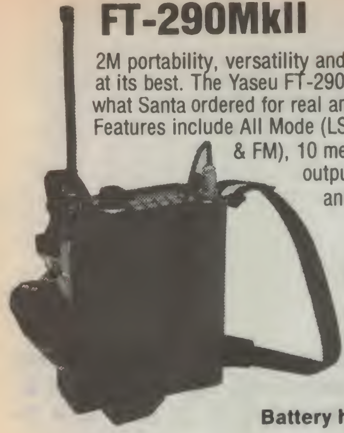

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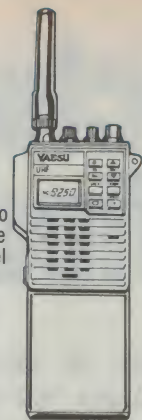

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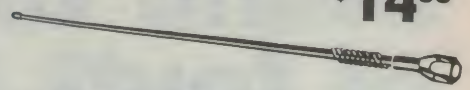

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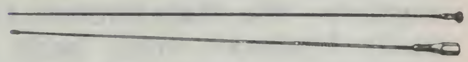

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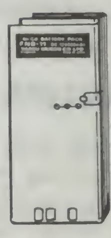

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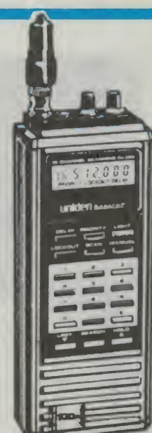

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DICK SMITH ELECTRONICS

Basic techniques of fault finding

Fault finding in electronic gear is like solving a murder mystery – the clues abound, but the 'red herrings' confuse the issue. However, many faults can be traced without needing expensive equipment and a high degree of technical knowledge. Too good to be true? Read on, and find out the things the text books don't tell you!

by PETER PHILLIPS

To set the stage, consider this short but true story that may illustrate the point of this article – a story related to me by a highly qualified electronics engineer.

Some years ago, I spent more time than I should have agonising over a fault in a popular model TV set. After a week of fruitless searching using all kinds of test equipment, circuit manuals, text books and theorising, I had to admit I could not find the fault.

I needed help, despite the embarrassment of this admission. So, on the pretext of inquiring about his health, I phoned a friend whose livelihood was TV servicing.

Following his advice and a spot of soldering around a terminal post totally remote to the area where the fault 'should have been', the set was soon working perfectly. Duly humbled, the obvious question I asked my friend was how he had originally discovered this fault.

His reply included comments on 'unnecessary theorising' and the appropriate use of 'basic methods'. In fact, he suggested that a lot of fault finding was best done with the 'non text-book' approach, and we theorists were wasting our time.

Of course, the 'bash it till it works' philosophy is not what this article is all about. However, there are many useful basic techniques that can help solve some very difficult fault problems – techniques that are rarely described. Certainly there is no substitute for technical knowledge, and readers cannot assume that all faults will yield their secrets by using the methods about to be described.

This article is therefore about fault finding, but based primarily on down-to-earth methods that servicemen have developed over the years. It purposely stays away from hi-tech methods, and may just provide you with a few ideas that could prove useful.

Faulty electronic equipment will either be commercially manufactured or home-built. As many readers get involved in building published projects, a separate article is being prepared for next month on how to fault-find projects. This type of equipment is more likely to have faults, either initially or subsequently, and, as such, it deserves an article of its own. For now, we concentrate on fault finding commercial equipment, although many of the techniques would apply to projects anyway.

I have always followed a few basic rules in servicing – rule 1 is always check the easy things first, even if this seems a waste of time. The second rule is to be methodical, and the third is to refer to rules 1 and 2. And now to elaborate...

Fault categories

A fault in a piece of equipment can be classified in three ways. The first is the problem occurring in a unit that, prior to the fault, worked normally. Called a *breakdown*, this type of fault is the most typical, and is generally the result of a component failure.

Another fault category is a construction error in a circuit, and is one likely to be encountered by hobbyists, both experienced or otherwise. The final type – the design error, is the nastiest and is often assumed by frustrated project builders.

Within the three categories given, there are sub-categories, such as the intermittent fault. Another is the possibility of two or more independent faults occurring simultaneously.

The breakdown

A fault in previously proven equipment will either be one or more compo-

Fault finding using high tech! Here the Polar B3T micro tester is being used in a microprocessor-based circuit.

nents, faulty connections, or a printed circuit board problem and may result from internal or external causes. Internal causes include ageing, poor design or even normal component failure. External causes can range from water damage (from the decorative pot plant sitting on top) to a lightning strike.

Commence by examining the events surrounding the fault – but don't always trust a third party description, particularly from the owner. Few people can be truly objective in describing a fault, particularly if they are embarrassed about the circumstances. Dropping the thing down two flights of stairs will often be described as 'a minor bump'.

Details to establish include any previous history of the fault, other related problems, even weather conditions at the time. Like solving a crime, any information that can give a lead should be sought.

Before removing covers, determine for yourself what faults the device is exhibiting. Identify unusual sounds, smells, visuals, vibrations, or behaviour of any sort. Try all controls, determine exactly what is working and what is not, and become very familiar with the specific problems.

Once clear on the symptoms, remove the necessary covers and visually examine the internals of the unit. As well, a bit of gentle probing may bring to light possible problems. For example, ensure all plug-in cards are correctly positioned, and test the integrity of any plug and socket combinations.

Also apply pressure to any components (ICs etc.) that are socketed, and generally satisfy yourself that the problem is not of the poor connection variety. Poor connections are a common cause of trouble. Naturally, do all of this with great care, turning off the power if any doubt exists as to safety for yourself or the equipment.

If the device is more than a few years old, it often pays to spray contact cleaner on all switches, plugs and sockets. Do this with the power off, and methodically separate all connectors, applying the spray (non-oily variety) to both sides of a connector pair.

Removing ICs from their sockets (using an IC extractor), and spraying the sockets is a part of this exercise, which even if unsuccessful in establishing the fault, represents maintenance of a useful type. Observe the orientation, and don't mix the ICs around.

PCB faults

Having ensured that the problem is more than a bad connection in a plug and socket, try the 'stress' test. The aim is to find any bad solder connections, or physically unsound components. Tapping lightly with the plastic end of a small screwdriver can often bring to light a poor soldered joint, as my engineer friend would agree. Sometimes, the tapping will even cause a faulty component to 'come good', even if only momentarily.

Because solder has little mechanical strength, likely soldering problems will probably be in areas where some physical strain is involved. Soldering associated with things like heavy components, areas subject to heating, PCB-mounted plugs or sockets should be examined carefully. Gently wobbling large components or terminal posts and observing the soldered joint can often identify a dry or broken connection.

Bad soldered joints may not manifest themselves for a number of years, and are the cause of many problems. Fig.1(a) shows some typical instances where soldered joints are likely to fail.

Flexing the board (gently) can identify possible problems with PCB tracks or connection points. If the fault is apparently corrected by distorting the board, localise the area as much as possible, then go to work with a magnifying glass and a soldering iron. Double-sided PCBs are prone to problems around the through-hole plating used to connect tracks on either side, and can be very difficult to find.

Careful resoldering of all connections in the suspect area often does wonders. Breaks in PCB tracks are not uncommon, particularly at the point where the track joins to the solder land. Some servicemen, after having tried everything else, run solder over every track in the hope of fixing invisible fractures.

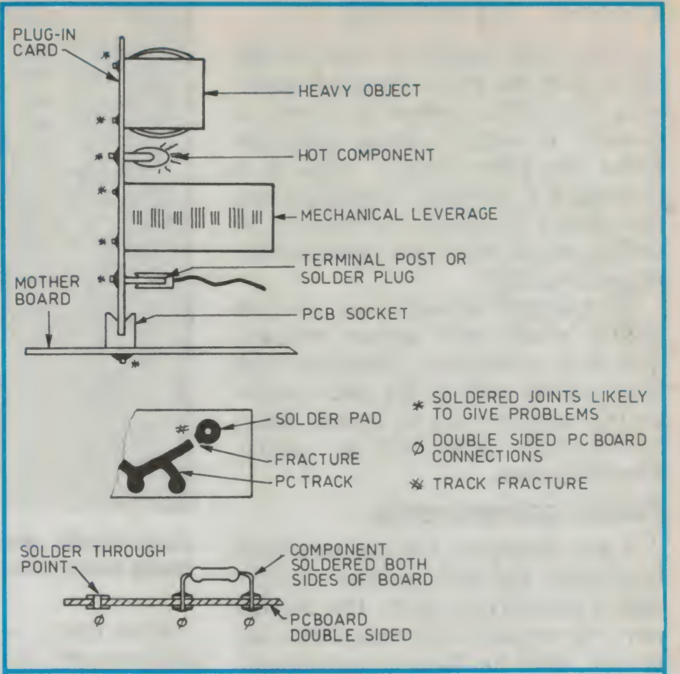
Repair of a track fracture should be done by overlaying a piece of wire across the break, soldering it into position after first cleaning the track where soldering is to occur. Fig.1(b) illustrates the technique.

Isolating the fault

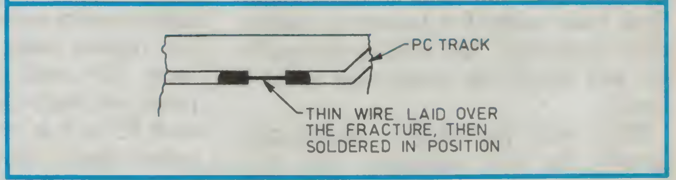
Sometimes the faulty section can be isolated using the 'half-split method'. As the name implies, the faulty area is found by first identifying which half of the circuit contains the fault. Having found which half, subsequent divisions of the suspect area may eventually lead you to the fault. This method is useful for audio equipment, where each section is relatively independent of the other.

For example, if the equipment contains an audio amplifier, applying a signal to the volume control will help identify if the fault is before or after the volume control. If before, don't waste your time on the later section.

PCB soldering faults are very common. If there is heat or mechanical stress around a solder point, sooner or later it will fail. Also, any plug and socket combination is a potential source of trouble, such as the PCB socket. Look also for track breaks around lands and other stress points. Another trouble spot can be plated-through holes that connect double sided PCBs.



Track repair should make the track physically strong as well as electrically sound.



Fault finding

If the audio section is dead, divide this section into power supply or audio, using any test to confirm that power is present. If heat is being generated within the power supply circuit it is probable it is working, although further tests should be used to confirm that all sections of the circuit are producing the required voltages.

The half-split method is not so easily applied where each section interacts, such as in a computer. However, each basic section, such as the clock oscillator in a computer can be treated singly, and mentally ticked off as working when so proven.

Faulty components

If the equipment has not responded to prodding and probing, then a component is probably the fault. The simplest way is to replace each component, one by one, until the fault is encountered. This basic method is known as component 'jockeying', and is often the quickest way where the component count is small.

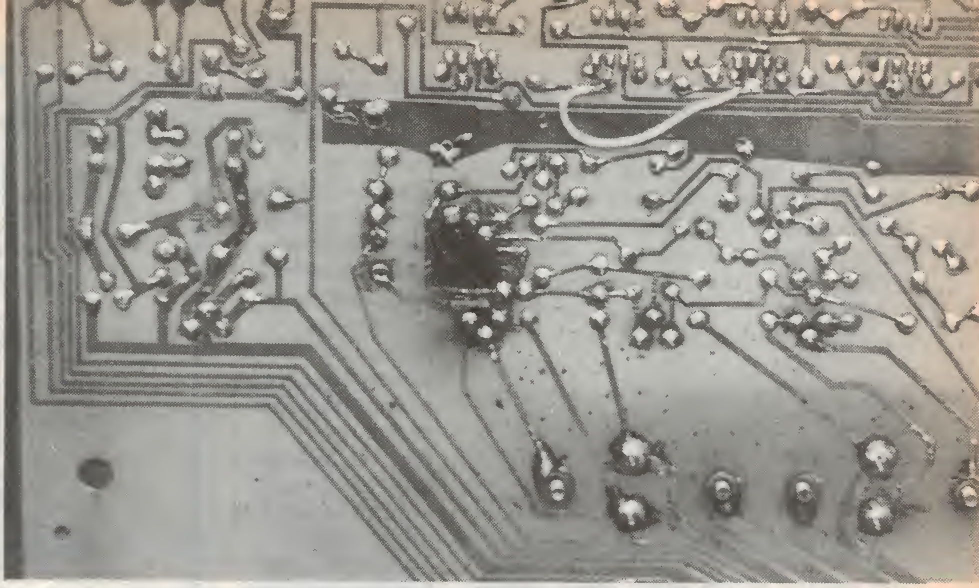
Start with the plug-in components, usually the ICs, replacing, one at a time, those ICs you have replacements for. Sometimes two ICs of the same type on the board can be swapped, and the effect noted. Always observe the behaviour of the unit after each component change, and be continually on the lookout for clues that may present themselves.

As a basic rule, try all the active components first. If a replacement is not available, test each component as thoroughly as possible, either in circuit or otherwise. Where there are a large number of components, an attempt should be made to identify the area containing the fault as already described.

Touching each component to determine its operating temperature can often identify either a faulty component or the problem area. A component that is 'stone cold', or one that is too hot may provide a clue.

Active components

Active components are basically more prone to breakdown than passive ones. As ICs are often in sockets, searching for a faulty chip is usually the best place to start. The quickest way to establish if an IC is faulty is to replace it, but it should be remembered that there may be more than one fault. Subsequently, when replacing an IC, leave it in the circuit even if the problem is not found, then go onto the next.



Some faults are obvious to the eye and the nose. Apart from replacing the faulty components, PCB repairs are also often needed.

Some faults, particularly those in the power supply, may have caused the demise of every onboard IC, and as fast as you replace them, so the fault destroys them. To avoid this expensive occurrence, attempts should be made to test each IC as it is removed. Naturally, the power supply should have been tested for correct voltages first anyway.

Testing a range of ICs is often difficult, but may avoid disaster on your stock of components. Trying each chip in another known piece of equipment can help find the faulty one, or at least prove that the ICs are working.

Device replacement, such as any transistors or FETs, should follow the IC replacement/testing process. However, if all the ICs are soldered in, then leave the ICs till last. Remember, do the easiest things first!

There are a few simple tests that can be applied to transistors before removal. For example, if the forward bias voltage between base and emitter exceeds 0.8V or so, it is almost definite that this junction is open circuit. Onboard ohmmeter tests are not always reliable, as parallel paths are likely, but lifting two of the three leads will allow correct testing.

However, the 'replace first, question afterwards' method is often the quickest way where the devices involved are cheap and available. I always compare my time against the component cost, particularly if the job is for money.

Where replacement devices are unavailable, methodical removal and testing becomes necessary. Ohmmeter testing of transistors is fairly well documented, and requires the testing of the two PN junctions. When using an analog meter, set it to its low ohms range, and remember that the polarity of the leads is generally reversed for ohms measurement. That is, the black lead becomes the positive potential. A digital multimeter retains the indicated polarity on ohms, but should be switched to its 'diode check' setting.

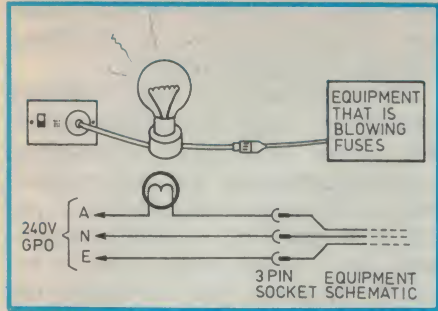
If all the ICs and transistors appear to be working, and checks have proven there is no bad connection, PCB track break or power supply problem, then the remaining components should be examined. Of great importance is to be wary of not accidentally introducing more faults during component replacing. Take care not to bridge PCB tracks, or to put a component in the wrong way. Only deal with one device at a time to prevent mixing them around, and always test the unit after each component replacement.

Capacitor faults

A valuable hint in fault finding equipment exhibiting peculiar faults is to test the capacitors associated with the power supply. If hum is present in a loudspeaker, a likely cause is a filter capacitor. Many a strange fault has been found by substituting a known good electrolytic capacitor across each of those in the circuit in turn.

Ensure the polarities match when the substitute is being attached and always discharge the test capacitor before reapplying it to another section. This is necessary in case the stored voltages obtained from one part of the circuit do damage to the next.

Electrolytic capacitors are the passive components most likely to fail with time. Equipment over ten years old that is being restored should have all the electrolytic capacitors replaced, as they



Simple, but effective means to protect fuses and equipment.

'dry out' or depolarise over the years, and lose their capacitance value.

Capacitors required to operate with voltages over 100 volts or so can become leaky, a problem very prevalent in valve equipment. Again replacement of the lot is recommended. Some capacitors can develop an intermittent open circuit – typical in the polystyrene variety.

Always replace a capacitor with one having a working voltage equal to or better than the original, and use the same type as far as possible. Paper capacitors can usually be replaced with polyester types, but inductance and stability considerations usually mean the original type must otherwise be observed.

Resistor faults

Resistors, diodes, transformers, wiring and so on can all become faulty. The possibility of this occurring is lower compared to the components already discussed, suggesting that these items are best checked last.

Resistors, particularly old style types, can change their value, and high value resistors are more prone to this than the low value types. Normally a resistor will increase its resistance with time and use. If a resistor indicates an in-circuit value higher than its marked value, replace it; if lower, lift one end and recheck.

In general, resistors are reliable unless their power dissipation rating is exceeded. Wire wound resistors are prone to becoming open circuit, even under normal operation, and this can often be found by noting that they are cold after the unit has been running for some time.

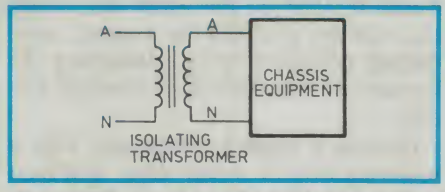
Power supply faults

Power supply faults are very common, and often hard to find, as the symptoms may suggest anything but a power supply problem. Digital equipment will behave very erratically if the power supply has excessive ripple, or if there is a bad connection between the power supply and the rest of the equipment.

I always examine the power supply first, mainly to confirm correct voltages and secure connections. As this section dissipates heat, faults are most likely to occur over time, depending on the thermal stresses within the section.

Power supply faults and the effects they cause could probably fill a decent sized book, as experienced technicians would no doubt agree.

Transformers and inductors usually go open circuit. Alternatively, transformers can 'burn out', usually obvious by the smell. In this case, find out why the transformer burnt out before replacing it.



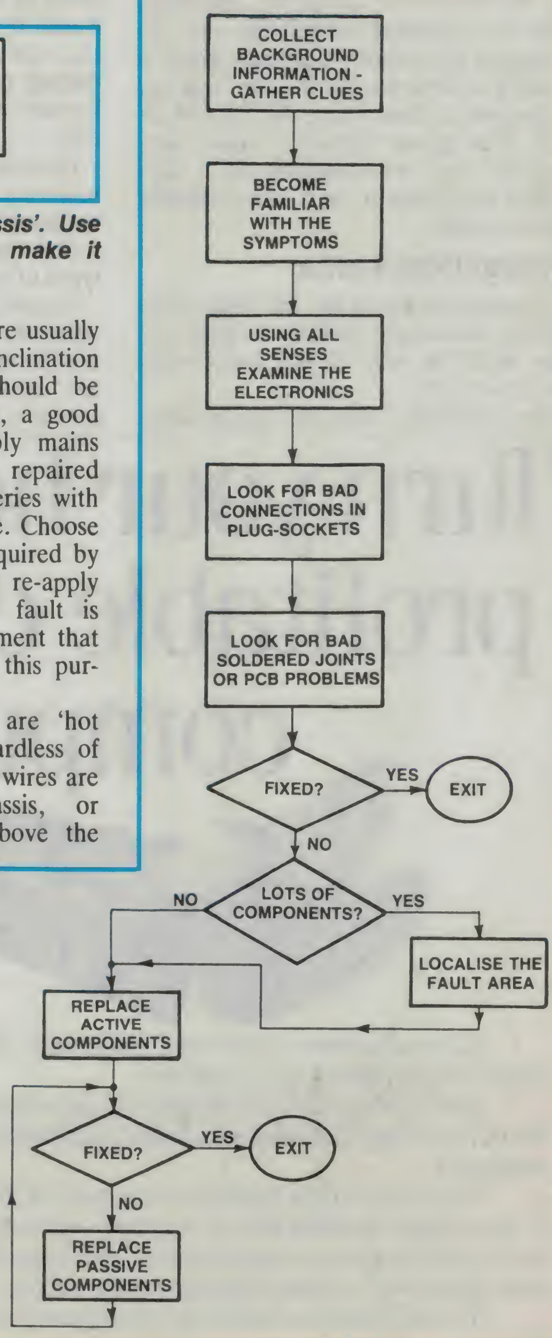
Many TV sets are 'hot chassis'. Use an isolating transformer to make it safe to work on.

Power supply transformers are usually protected by a fuse, and the inclination to increase the fuse rating should be avoided. If fuses are blowing, a good servicing technique is to apply mains power to the unit being repaired through a 240 volt lamp in series with the power point and the device. Choose a wattage up to twice that required by the unit under test, and don't re-apply the mains directly until the fault is fixed. Fig.2 shows an arrangement that can be easily constructed for this purpose.

Many domestic appliances are 'hot chassis'. This means that regardless of the way the active and neutral wires are connected, the metal chassis, or 'ground' of the device, is above the earth potential. Connecting an earth wire from a piece of test equipment can result in damage to the device being repaired, blown mains fuses, or destruction of the test equipment.

Also, the technician is exposed to a very dangerous situation, running a great chance of receiving a lethal electric shock. This makes the use of an isolating transformer (240V to 240V) essential. The power rating of this transformer should equal or exceed that of the equipment. *Note particularly that a 'Variac', or variable auto-transformer is NOT suitable for this task.*

Diodes can become either open or



Rules:
1. Don't rush in. Examine the symptoms first.
2. Do the easy things first.
3. Locate the faulty section.
4. Be methodical.

A fault-finding flow chart that must work.

Fault finding

short circuited. Power diodes in a bridge circuit usually go faulty in pairs, but it is good practice to replace the lot anyway. Be careful to use diodes that match the original, particularly in terms of their PIV (peak inverse voltage) and current ratings.

As already mentioned, power supply capacitors often become faulty, especially the main filter capacitors. It is important to replace any such capacitor with one having the same temperature and current ratings (match the physical size) as well as voltage rating.

Another consideration is the possibility of electrolytic capacitors exploding due to an internal temperature rise. To minimise the danger, a pressure relief is usually incorporated in the can, and any replacement should have this type of relief. This mainly applies to those electrolytics that are operating in a high power environment, such as a computer power supply.

Intermittent faults

Intermittent faults are the bane of the service technician. Difficult to find, you can never be sure if you have really fixed the fault.

Bad soldered joints are typical intermittent faults, and it often pays to simply spend the time to carefully resolder every connection on the board. Special care is needed, as long term oxidisation effects can make the faulty connection difficult to repair properly.

An intermittent fault in a component can often be found using a can of freezer spray. If the general area of the fault can't be identified, spray methodically over the whole board. If the component is temperature sensitive, this technique will often find the problem.

If the fault only appears after a certain operating temperature has been reached, normal operation will follow when the faulty component is cooled down by the spray. By using a localising nozzle or tube on the spray can, its effect can be confined to a small area, helping considerably in establishing the location of the fault in a crowded layout.

Heating a suspect component with a soldering iron or a hair dryer and then applying the freezer spray is another effective method for seeking out these types of problems.

In some cases, particularly in complex equipment, it becomes impracticable to use the methods described above. When the intermittent is not temperature sensitive, and all soldered joints have been tested, it becomes essential to narrow the problem down by identifying the area causing the problems.

Various methods are used, including transferring plug-in cards from another unit of the same type, or attaching analysing equipment. The main requirement in this type of fault finding is patience. If parts are available, components for a whole section can be replaced. Of course, you can replace the lot to begin with anyway, in the hope the fault is a component.

Handy flow chart

Fig.4 shows a flow chart that summarises the fault finding techniques described so far. No flow chart can cover all situations, but the suggested 'plan of attack' is a good place to start. Experience will soon show you how to adapt the chart to particular situations, and its presentation is included merely as a pictorial means of summarising this article.

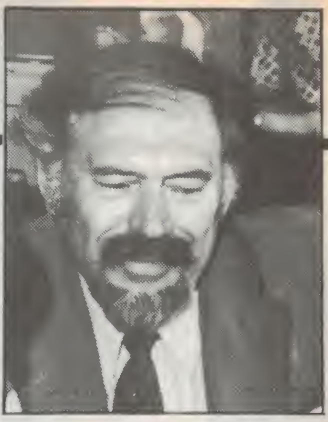
Included with the chart are four basic rules. The rules are not in any specific order, but the intended message is to be scientific and logical about the task. Luck has always played a part in servicing, but you can never rely on it.

Remember that if the device used to work, then it will again – given enough time and effort.


Experience
Counts.
ez-pro
8048
6309
80286
6801
6805C4
8086
8088
64180
8X305
68HC11

Frankly Frank

Musings on matters electronic by FRANK LINTON-SIMPKINS



That Quark was a Coojum, you know...

Imagine a strand of viral material – pick your own favourite virus – orbiting the sun out around Uranus. Imagine if you will another virus orbiting in the other direction, but in the same orbit. Further imagine that these two strands of viral material crash head on into one another. If your mind has that sort of ability to imagine, then you have roughly the idea of what the Americans hope to make their super-conducting super collider do when they get it finished.

The device, instrument or what you will, will accelerate streams of protons to vast energies approaching 20 trillion electron volts, energies that prevailed just a fraction of a second after the Big Bang.

To do this the size of the device is just within rational human contemplation. It will have an oval track just short of 84 kilometres long, the streams will be aimed and controlled by 10,104 magnets weighing a mere 42,250 tonnes, with some 19,200 kilometres of superconducting cable cooled by more than 2.2 million litres of liquid nitrogen.

The SCSC will cost the American people about $US30 per head (men, women and children). Now this $US30 per head may come as rather a shock for some Americans, who could not care less if a quark, a Higgs boson or any of the now seeming hundreds of sub-atomic particles exist.

The cash cost won't bother too many adults, but on the other hand the small fry had other plans for their life's savings – Springsteen records, bulk Hershey bars, tickets to Crocodile Dundee II, a little Tijuana Red, some Maui-Wowie or massed Big Macs. All this to produce quarks, assorted leptons and those Higgs bosons, although there is some cloud over the latter since some dissenters feel it didn't exist even at the moment just after the Big Bang.

So why build this gigantic thing in the first place? With that sort of money you could probably end the world's food shortage for ever, develop a cure for cancer or AIDS, build colonies on the moon, buy the Contras out of the drug trade and we could all live happily ever after.

But these wonderful things won't happen, as the building of the Superconducting Sypercollider would have a far better result. Namely, the ensuing employment opportunities for the area where it will be built – in order to make certain the re-election of the local Congressman and at least one of the two Senators for that State.

During construction the thing would mean 4,500 new jobs lasting years. Then the running costs to the US government would be $US250 million per year, much of it ultimately spent in the towns not far from the SCSC.

So at last count 43 towns in half of the US states had tendered proposals to the Government asking to have the SCSC located in their backyards. The decision to go ahead and the location of the SCSC (Congress hasn't voted the money yet) will not be made until January 1989 – so Ronnie won't be in office to push the start button.

Looking at the SCSC and placing it in an Australian perspective, we see that it could just fit into the space between Penrith and the sea, in Sydney, with the long axis of the oval making life difficult for people as far south as Camden and as far north as Hornsby.

Mind you the only real problems with having the thing in your town might be that your anti-magnetic watch would go into overload condition, and any hopes you might have harboured about eventually getting SBS could be written off.

There may also be problems with the results of the proton collisions, an estimated 100 million each second. The leptons, quarks, Higgs bosons etc would be travelling in close formation with light rays, and they may not be easy to bring to a halt before they encounter any passing living tissue. Mutate now and avoid the rush, as some Sydney graffiti used to suggest.

But it may be that we won't have to worry about Americans growing extra legs, being born anancephalic etc., as many US projects of scientific promise seem to come unstuck.

Take the far-famed SDI or Star Wars project. At least two of the main components of Star Wars, the X-ray laser and the space-borne chemical laser have run into problems.

The chemical laser operates in prototype form, but since it weighs in at around 200 tonnes it will be some time before it can be launched. The X-ray laser, the one that is to be triggered off by the detonation of a nuclear bomb in flat contravention of an earlier pledge to keep nuclear arms out of space, has fallen foul of the laws of physics and Dr Edward Teller's somewhat uncritical championing.

Since the laser would be destroyed by the same atom bomb that powered it, the American people wouldn't know if it worked or not until the missiles began landing. By that time they mightn't have the thinking time left to realise that Teller had been telling a few scientific/Hungarian porkies.

Dr Teller, the sworn foe of Robert Oppenheimer and the maker and prime thruster towards the development of the hydrogen bomb, gave what other scientists are now saying was misleading information to government and was over optimistic about the concept's feasibility during 1984-85.

Originally intended to knock out missiles in flight, the X-ray laser is still not dead. It has merely changed roles, to that of satellite killer – they are much easier to hit. The whole X-ray laser project is now seriously under scrutiny on a cost-per-satellite-kill basis. Ah, true it is that the auditors are always with us and they'll get us all in the end, no matter how we try.

But in case you feel that the Americans are in danger of letting down the free world, what with playing footsie with Mikhail Sergeivitch Gorbachev and pulling the money plug on Teller's magnum opus, I must tell you that that for a mere $US75 you can get a 35.56cm high porcelain doll with individually tailored uniform of the Vulcan, Mr Spock of the *Starship Enterprise*. Truly our cousins do tend to boldly go where no man has gone before.

In case you might have worried, the doll is the first 'Officially Authorised' Star Trek doll – and if you don't accept my word, I'll have Scotty beam you up and give you to the Klingons.

Do not concern yourself if Mr Spock isn't your favourite character. Captain Kirk, Bones, Scotty and Lt Uhura will follow. Wasn't there a sort of pre-dawn Glasnostnik called Chekov on board as well? You can bet his doll will have a lowish priority. In fact the Chekov doll will probably remain below the event horizon.

Meanwhile, back at the beam-switch yard on the SCSC and the American obsession with learning all about the Big Bang and the time immediately after it happened. Perhaps if they had waited a mite longer they might have been able to observe the big bang in action.

Three astronomers from the University of Arizona have sighted a couple of galaxies that are around 17 billion light years away. That is, the light which we have detected from them left home 17 billion years ago – or just after the Big Bang.

These newly seen primeval galaxies probably represent the limit of the observable universe with presently available technology. If we wait a while and work hard on detection systems, it may be possible for us to witness a much delayed action replay of the moment of the Big Bang, and not just be able to detect its gravity waves. So no SCSC. So no more $US250 million per annum spent in some politician's area, no 4,500 jobs, no outlay of $30 per head for all US men, women and brats.

What am I saying? If I am correct this may be the end of the political/democratic process as we know and love it. The end of closing meatworks near major cities, to give work to meatworks out in the electorates of party heavies. Pork barrelling would go with the SCSC.

No, we can't wait for the pictures of the big bang to arrive. We must have our big bangs in miniature and keep our politicians in their seats, our Edward Tellers in Tokai and Hobbes in his Leviathan. EA

Compact Disc Reviews

by RON COOPER

CELLO PIECES

The Sound of Cellos
The Yale Cellos
Aldo Parisot
Delos D/CD3042 DDD
Playing time: 63 min 54 sec

PERFORMANCE
1 2 3 4 5 6 7 8 9 10

SOUND QUALITY
1 2 3 4 5 6 7 8 9 10

Here is a different disc, if ever there was one. All cellos, performing full orchestral pieces with almost unbelievable dexterity. Naturally the sound is different from an orchestra so if you like cellos – lots of them, this disc is for you.

The selections are: *Kanon* (Pachelbel), *Allegro non molto* and *Largo* (Vivaldi), *Adagio* (Albinoni), *Flight of the Bumblebee* (Rimsky-Korsakov), *Vocalise* (Rachmaninoff), *Concerto in G minor* (Handel), *Requiem and Elfentanz* (Popper), *The Entertainer* (Joplin), *Largo* (Veracini).

The 'Flight of the Bumblebee' and the viruoso solo *of Popper's Elfentanz* by Mark Tanner are quite stunning and almost beyond belief.

The playing right through is excellent and certainly shows cellos in a different light, under the very skilful and dedicated conductor Aldo Parisot.

The recording is very good with no noise and a fair amount of reverberation. It would certainly be a must for students of the cello.

RICHARD STRAUSS

Thus Spake Zarathustra
Salome
Dance of the Seven Veils
Intermezzo Symphonic Interludes
Seattle Symphony
Gerard Schwarz
Delos D/CD 3052 DDD
Playing time: 70 min 58 sec

PERFORMANCE
1 2 3 4 5 6 7 8 9 10

SOUND QUALITY
1 2 3 4 5 6 7 8 9 10

The tone poems of Richard Strauss are not exactly music for newcomers to classical music (though most will recognise the opening bars of this one, as it was used in the film 2001). This music requires many hearings for familiarity and the notes on this recording include exact timing marks to enable you with the aid of a stopwatch etc., to follow each section precisely – an excellent feature.

Strauss conceived this work, which is based on a prose poem by Nietzsche during a convalescent visit to the middle east in 1892 (how times have changed!), and was completed in 1896. The work is meant to convey an idea of the evolution of the human race from its origin through various phases of development.

The orchestral playing is first class and the recording balance very good, but not spectacular. The miking seems to be somewhat left-right but quite spacious and of course there is zero background noise which is mandatory for this music.

As a bonus and a contrast this disc also includes the 'Dance of the Seven Veils' and the 'Four Symphonic Interludes from Intermezzo'. These are later works, the latter completed in 1923.

For people interested in Richard Strauss, this disc represents extremely good value.

FOLK MUSIC

Two Gentlemen Folk
Benjamin Luxon,
Bill Crofut & Friends
Telarc CD-84401 DDD
Playing time: 56 min 38 sec

PERFORMANCE
1 2 3 4 5 6 7 8 9 10

SOUND QUALITY
1 2 3 4 5 6 7 8 9 10

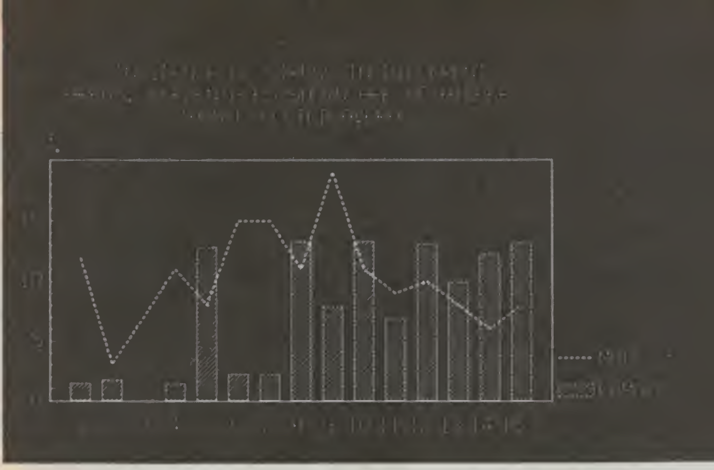
Here is a recording of folk music which is polished in the extreme. The voices and instrumentation are quite exemplary and I have never heard this style of music sound so delightful. There is a great deal of sensitivity between both the vocal and instrumental parts.

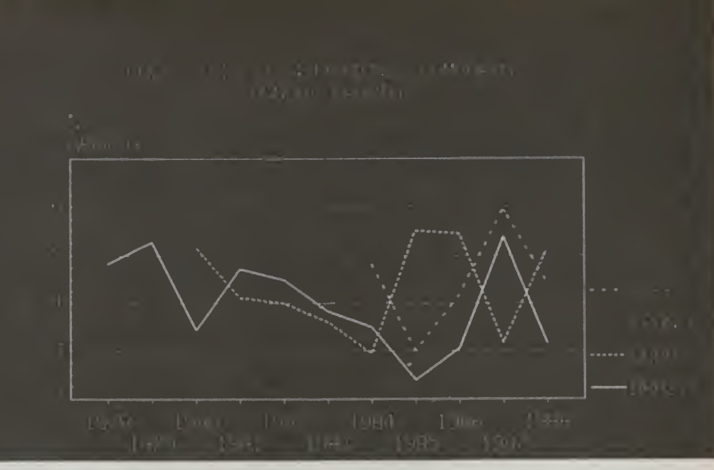
Although I was unfamiliar with most of the tracks, they are very easy to listen to and the overall sound is quite stunning and a credit to the Telarc engineers.

The tracks are Sweet Nightingale; The Tinker; The Leaving of Liverpool; She's Like the Swallow; Dance to your Daddy; The Ash Grove; San Francisco Bay; Danny Boy; White-haired Cassidy (pennywhistle solo); The Cuckoo/Leatherwing Bat; Turkey in the Straw; The Flowers of the Forest; Bold Nelson/Eddystone Light; Waly Waly; Waltzing Matilda and The Wabash Cannonball.

The cover notes include all the words, so that it is easy to follow or sing-a-long as you wish. They are also very interesting, pointing out the humble beginnings of the group by Bill Crofut and Benjamin Luxon in a pub after they had rehearsed in a production of Bach's 'St. Matthew Passion' with the Munich Bach Choir under Karl Richter.

This disc has achieved an excellent result and should have wide appeal.





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CSS: As large as DOS allows	**SPSS/pc+:** As large as DOS allows
GRAPHICS	
CSS: Large selection of colour, hi-res, quality graphs, very flexible interface between numbers and graphics (all CSS output can be converted into a variety of graphs; also, user selected results from different CSS analyses can be easily combined in a single graph).	**SPSS/pc+:** Limited character based graphs, rigid interface between numbers and graphics.
USER INTERFACE	
CSS: Fast hierarchical menus; the entire user interface is optimised to limit the number of keystrokes necessary to perform an analysis; fast selection of individual variables or lists of variables; previous variable selections are "remembered" (and can be edited) across consecutive analyses; batch processing is also supported.	**SPSS/pc+:** Command language; some commands are several lines long (in case of a typo, e.g., a misspelled variable label, the entire command has to be re-typed); commands can also be submitted via batch files.
PROCESSING LISTS OF VARIABLES	
CSS: Supported by all procedures (where applicable, lists of dependent variables can be automatically processed with the same design, e.g., in t-tests, Crosstabulations, ANOVA, Regression, etc.)	**SPSS/pc+:** Supported by all procedures (where applicable, lists of dependent variables can be automatically processed with the same design, e.g., in t-tests, Crosstabulations, ANOVA, Regression, etc.)
SELECTION OF SUBSETS OF CASES FOR ANALYSES	
CSS: Yes (on line selection of cases via "include if" or "exclude if" selection conditions that remain in effect for the entire CSS session or until cancelled; the selection conditions can be saved for repeated use)	**SPSS/pc+:** Yes (via logical "select if" conditions
SCREEN DISPLAY OF OUTPUT	
CSS: All CSS output is displayed via Scrollsheets. These are dynamic, scrollable, user controllable, multi-layered tables with cells expandable into pop-up windows. All numbers and labels (or selected subsets) in Scrollsheets can be instantly converted into a variety of presentation quality graphs. The contents of different Scrollsheets can be instantly aggregated, combined, compared, plotted, printed, or saved.	**SPSS/pc+:** Output scrolls across the screen (a "MORE..." prompt appears when the screen is full.
DISPLAY FORMATS FOR NUMBERS	
CSS: Flexible; all display formats are dynamically adjusted to yield maximum display precision while preserving compatibility of formats within columns of numbers; special extended formats are available where applicable (B-weight =·094027563759532)	**SPSS/pc+:** Fixed, regardless of value (e.g., if values are very small, SPSS cannot display them with sufficient precision)
PRINTING	
CSS: Selective printing or saving of results (e.g., only specified tables with results, or subsets of tables); all results can also be automatically printed (or saved) in formatted reports; graphics can be printed on all plotters, dot matrix, colour, and laser printers. (including printers supporting PostScript)	**SPSS/pc+:** Only via dumping all screen output from an analysis to the printer or file; hi-res graphics are not available.
ACCESS TO INDUSTRY STANDARD FILE FORMATS	
CSS: Intelligent read/write interface to (unlimited size) Lotus, dBII, dBIII+, DIF, SYLK, and a variety of formatted and unformatted ASCII files; CSS imports not only data values but also formats, labels, headers, logical variables, missing data codes, etc.	**SPSS/pc+:** No (only ASCII; an optional file conversion package is available)
SUBMITTING OUTPUT FROM ONE ANALYSIS AS INPUT FOR ANOTHER	
CSS: In addition to matrices (corr., cov., etc.) and scores that are calculated for each case (e.g., residuals, factor scores), all other numbers generated with CSS analyses can be converted into the CSS data file format.	**SPSS/pc+:** Only matrices (corr., cov., etc.) and scores that are calculated for each case (e.g., residuals)

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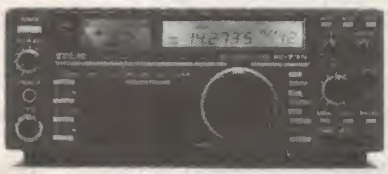

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- 100W output

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- 100W output
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- High grade SSB filter standard
- Optional mains power supply can be built in

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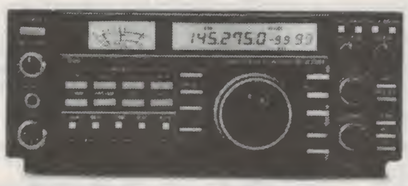
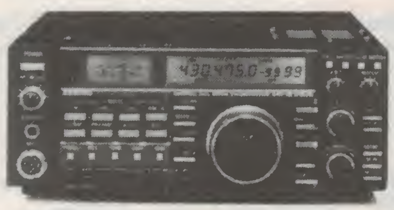
28/50 MHz All Mode Transceiver
- Receiver coverage: 26-56 MHz
- Direct digital synthesizer (DDS)
- 99 memory channels
- Built-in AC power supply (IC-575A)
- Passband tuning



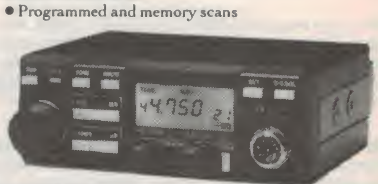
IC-275A (25W) **IC-275H** (100W)
144 MHz All Mode Transceiver
- Direct digital synthesizer (DDS)
- 99 memory channels
- USB. LSB. CW. FM
- Built-in power supply (IC-275A)
- Passband tuning
- Designed for packet mode



IC-475A (25W) **IC-475H** (75W)
430 MHz All Mode Transceiver
- Direct digital synthesizer (DDS)
- 99 memory channels
- USB. LSB. CW. FM
- Passband tuning
- Adjustable IF notch filter
- Designed for packet mode

MOBILE TRANSCEIVERS

IC-228A (25W) **IC-228H** (45W)
144 MHz FM Transceiver
- Compact and easy to operate
- 20 memory channels
- Multi-colour LCD
- Programmed and memory scans



IC-28A (25W) **IC-28H** (45W)
144 MHz FM
IC-48A (25W)
UHF FM
- 21 memory channels
- UFO and memory scans

RECEIVERS

IC-R71A
HF Communications Receiver
- USB. LSB. AM. FM. CW. RTTY
- 32 memory channels
- Programmed memory & mode scans
- Passband tuning

IC-R7000 VHF UHF
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- Wide frequency coverage
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- Six-band flexibility
- Full duplex crossband operation
- 10 memory channels per band

28 MHz
50 MHz
144 MHz
430 440 MHz
1200 MHz

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- Full duplex crossband operation
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- Pocket size
- Automatic power saver
- 10 memory channels

IC-μ2AT
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FM Transceiver

- Splash resistant
- RX & TX incremental tuning (VXO)
- Automatic power saver
- 20 memory channels

IC-12GAT
1200 MHz
FM Transceiver

- 5W output with BP-7 or BP-70
- 10 memory channels

IC-02AT
144 MHz
FM Transceiver

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FORUM

Conducted by Jim Rowe

Further thoughts & theories about oxygen-free copper...

Remember the discussion in the September issue about the use of "oxygen-free" copper in electronic gear? My original attempt to get hold of some further information from Japan drew a blank, but a reader in Melbourne has very kindly sent me copies of some papers by one of the leading Japanese researchers, and these throw some interesting light on the subject.

The reader concerned is Mr John Ulph, engineering manager of Alcatel STC-Cannon in Melbourne, and I'm very grateful to him for sending this material. But before we have a look at it, I'd like to quote from another letter which turned up, also with suggestions on the subject of OFC and its possible benefits in audio applications.

This letter came from Melbourne as well, from Mr Robert Vickers of Mount Waverley. And Mr Vickers believes that in the September discussion I could have overlooked a key point:

I suspect you may have just missed the rationale behind OFHC (as per Colin Campbell) in applications using multistrand signal wiring – either in links, preamps etc., or speaker cable.

As I understand the situation, AC is conducted along the surface of a conductor, rather than through the core. According to Colin Campbell, OFHC can be drawn into finer wires which have tightly bonded oxide layers on the surface. At typical hi-fi voltages, presumably two such layers would form an insulator. One can therefore manufacture a cable with many fine, insulated wires, giving a large conductive 'surface'.

I further suggest, without wishing to enter the audio-fanatical world of the 'golden-eared' audiophiles, that the signal entering one end of such a cable comes out unchanged – that is, ungarbled by random signal path lengths as electrons randomly swap from one wire to another.

I won't comment on structural uses but suffice to say, be it 'hype' or 'tripe', they need a gimmick to sell a new machine while the old one is still working.

Thanks for the comments, Mr Vickers. You're quite right too, in suggesting that I had overlooked the possibility of skin effect. I hadn't considered the other aspect you raise either, about the effects of electrons swapping from wire to wire and thus causing random variations in path length. They're both interesting ideas, although I'm not sure that they really help all that much in explaining the advantages of OFC (oxygen-free copper) or OFHC (oxygen-free high conductivity copper).

For example skin effect, or the tendency for AC to flow near the surface of a conductor rather than at its centre, doesn't really become significant in ordinary wires and cables until you get to frequencies well over 100kHz. That's because it's the result of differences in the effective inductance of the inside of the wire, compared with its outer layers. As inductive reactance is proportional to frequency, this makes it only become relevant at higher frequencies.

Just to refresh my memory about this I looked it up in that well-known engineering text *Electronic and Radio Engineering*, by the famous Frederick Emmons Terman of Stanford University. Here it quotes the effective skin conduction depth in copper at 20°C as given by 66.2mm divided by the square root of the frequency in hertz. If you work this out, you find that the skin depth at 20kHz is nearly half a millimetre – larger than the total diameter of the individual strands in a typical multistranded audio cable.

The depth is still more than 200um at 100kHz, falling to 93um at 500kHz and 66um at 1MHz. So its effect is really only likely to be significant at these frequencies and above – not down in the audio range.

In any case, I find it a little hard to see how skin effect would work to produce an advantage for OFC. If OFC has its remaining oxides concentrated on the outside surface, as Colin Campbell noted, that's surely the very place we *wouldn't* want the current to be trying to flow, in preference to inside the copper!

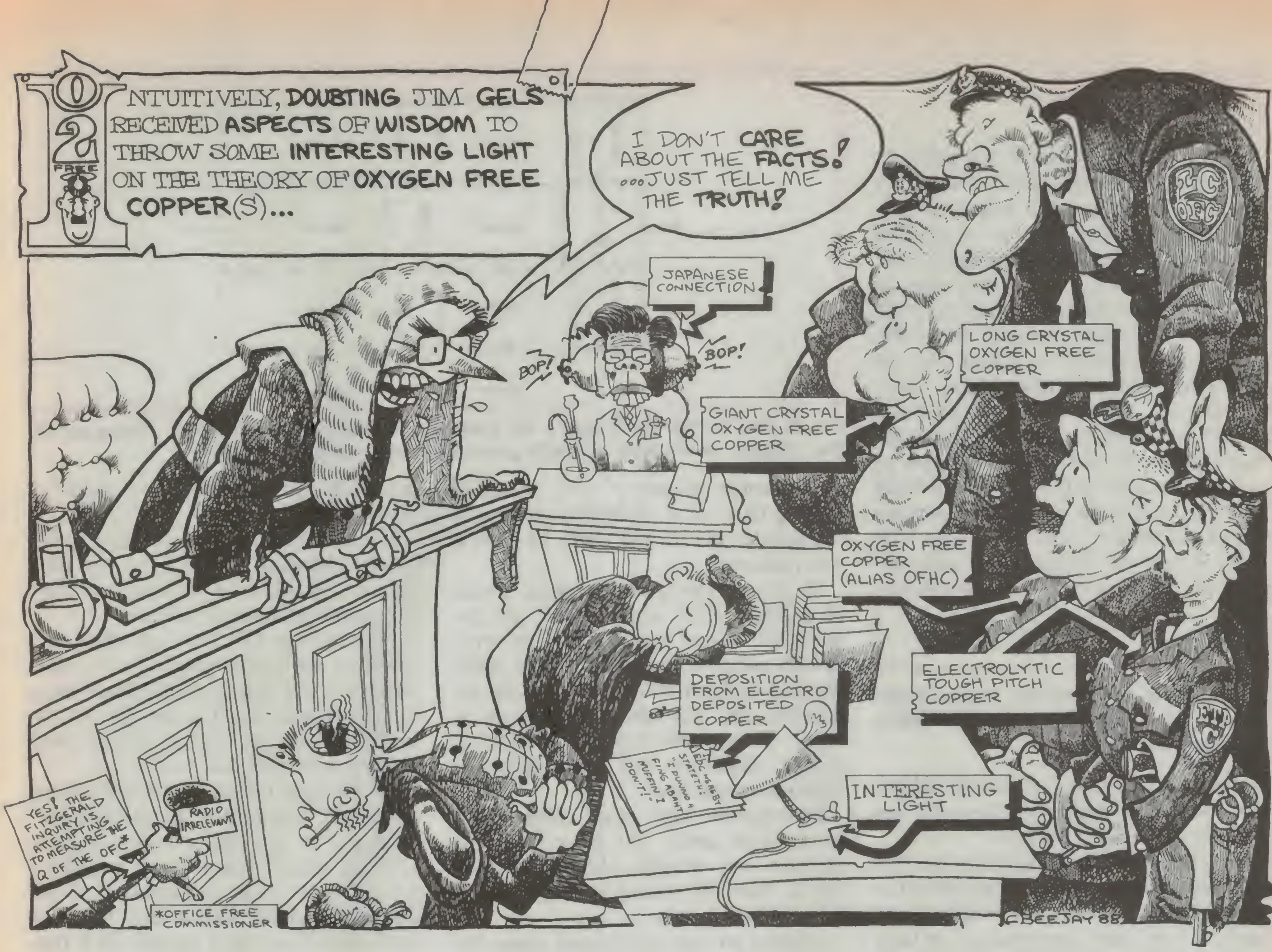
In fact if skin effect were relevant at audio frequencies, I suspect this would be more of a factor in favour of ordinary ETP (electrolytic tough pitch) copper, not OFC. At least with ETP copper the region of the wire nearest the skin wouldn't be any poorer a conductor than that further inside...

Actually Mr Vickers' other point seems in some ways a little more promising – the one about OFC's outer layer of oxide possibly acting as a kind of insulation between adjacent strands of wire in a multi-strand audio cable. On the surface this sounds as if it might be a possibility (sorry about the pun), as copper oxide is a semiconductor and in conjunction with copper metal forms a rectifying junction. After all this is how the old copper-oxide rectifiers worked.

Surprisingly, I haven't been able to find much technical information on the exact electrical properties of this kind of junction. Although copper oxide was one of the first semiconductor materials discovered, very little seems to be known about it.

I did glean from R.A. Smith's classic book *Semiconductors* that it has an energy band gap of around 1.9eV at room temperature, compared with 0.67eV for germanium and 1.12eV for silicon. This perhaps gives some support to my recollection of copper oxide/copper junctions as having a fairly high forward conduction voltage, and as being rather less efficient than either germanium or silicon.

But be that as it may, it does seem likely as Mr Vickers' suggests that two



such junctions effectively back-to-back (between adjacent strands of wire) would form an insulating layer, preventing electrons from crossing back and forth between them. Both because they're back-to-back, and because the voltages between the strands would very likely be below their forward conduction 'knee'.

This assumes, of course, that the two layers of oxide are continuous and entirely covering the surfaces of all strands. This might be a big assumption, because according to Colin Campbell the oxygen content of OFC is around .0003% – that's not much left to form oxides anywhere, let alone all over the surface.

Let's assume that it does do this, though, and that as a result a multi-stranded wire of OFC does act like many individually insulated strands. What effect would this have on the audio signals?

Mr Vickers suggests it would ensure that the overall signal path would stay 'more constant', with less 'random modulation' due to sideways motion of the electrons between strands. But frankly I can't see that the additional effective path length would be significant at audio frequencies, considering the speeds that conduction electrons would be travelling at in a metal like copper.

Don't forget that the random thermal motion of the electrons is quite great at room temperature anyway, producing what we normally call *thermal noise*. So as far as I can see, what Mr Vickers seems to be saying is that a cable with many strands of OFC would be less noisy than one of ordinary ETP copper, because the latter lacks our hypothetical layer of copper oxide insulating the strands.

If this were true, you'd expect a single large diameter wire to be much more noisy than our multi-stranded cable, even if the large diameter wire were made of OFC. In other words, Mr Vickers seems to be saying that the fatter a wire is, the more variation there will tend to be in conduction path length due to sideways detours by electrons, and hence the more noise added to the signal. And when you put it that way, it doesn't seem likely, does it?

I suppose it's possible, but you'd normally expect a single large-diameter wire to present the lowest resistance, and there's another law that links thermal noise directly with resistance. Intuitively I'd expect it to provide a connection that was *less noisy*, not more.

So you could be right, Mr Vickers, but I have my doubts. The ramifications of what you proposed don't quite seem to gel with other aspects of received wisdom.

With those comments as preamble, perhaps we can now pass on to the information sent in by John Ulph of Alcatel STC-Cannon. Mr Ulph's company is the Australian representative for Hitachi Cable Ltd., of Tokyo, and the information actually originates from that firm – which appears to be one of the major manufacturers of OFC cables for audio and video applications.

Much of the material turned out to be reprints of papers written by the chief engineer of Hitachi Cable, Mr Osao Kamada, who seems to be one of the leading researchers in the field of OFC applications in electronics. As it was therefore the first really authoritative information on this specific subject to come my way, I found it of great interest. And I think you will, too.

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One paper in particular attracted my attention. It was apparently written for the Journal of the Japan Audio Society, and was essentially a review of progress to date in the field of OFC applications.

In it, Mr Kamada writes that although quite a few researchers in various parts of the world had noticed that OFC audio cables produced a sound that was somehow 'crisper', 'richer' and 'more transparent' than when conventional copper was used, for a long time no-one could show the difference by means of any electrical measurements. Nor could anyone really come up with a convincing explanation of why the results with OFC *should* be better, until quite recently. (So I guess *we* shouldn't feel too bad about not being able to come up with an explanation, either!)

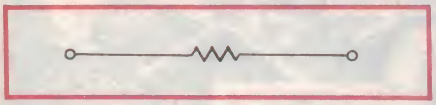

Fig.1: Most of us think of a copper wire as simply a low-value resistance...

By the way, Mr Kamada notes that because of the observed improvement in sound quality gained from OFC, firms such as Sony have been using it in their equipment for quite a while. Apparently the headphone cables on Sony's highly successful 'Walkman' have used OFC wire for about 8 years. So despite the lack of objective measurements, even a highly respected and engineering-driven firm like Sony decided that the benefits were tangible enough to proceed. An interesting point, don't you agree?

It turns out Mr Kamada was convinced that the improved sound quality provided by OFC must somehow be due to the fact that its copper crystals had very much less copper oxide concentrated at the boundaries between grains. The amount of oxygen in the copper is about 100 times less (3-5 parts per million, compared with 300-500ppm) than for ETP, so you'd expect the amount of copper oxide at the grain boundaries would be reduced by pretty well the same ratio.

Knowing that copper oxide was a semiconductor, he came to much the same conclusion as our reader Mr Vickers: that the effect of these thin regions of Cu_2O at the grain boundaries would be to upset the conduction between them. Either by introducing an element of non-linearity, due to the rectifying action, or at the very least acting like a small series capacitor and therefore causing changes in conduction at various frequencies due to the effect of capacitive reactance.

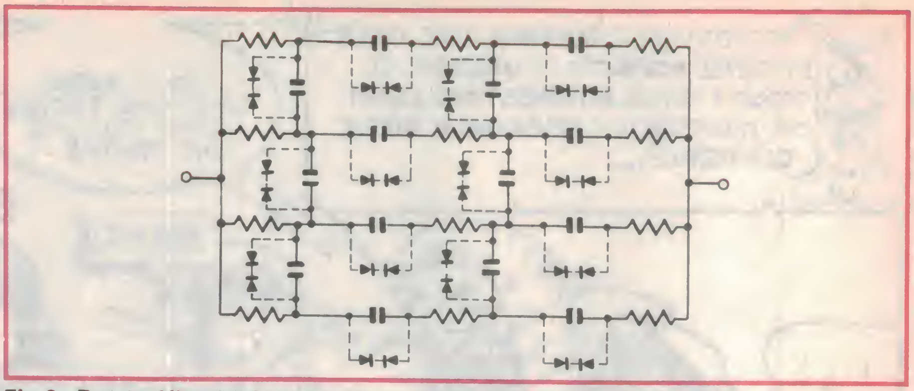

Fig.2: But to Hitachi Cable's Mr Kamada, it looks more like this – because of the copper oxide layer at each grain boundary in the copper.

So he speculated that perhaps a wire of ordinary ETP copper didn't just behave like a low-value resistor as we'd always assumed, as in Fig.1, but more like a complex network of resistors, capacitors and perhaps diodes – as in Fig.2. This would suggest all sorts of strange amplitude and phase effects at different frequencies.

Presumably wire made from OFC would have about 100 times fewer capacitors and possible diodes per unit length, and this would perhaps explain the 'clearer' signals.

Because so little was known about the precise AC behaviour of Cu/Cu_2O junctions, Mr Kamada made up some sample diodes and tested their performance. Apparently there were indeed significant amplitude and phase variations even over the audio frequency range...

Of course this was making measurements on relatively gross and 'discrete' junctions, and Mr Kamada apparently realised that you couldn't necessarily assume that these results would automatically apply at the microscopic level inside a wire. So he carried out another experiment, this time comparing the Q of physically identical microstripline resonators made from OFC, ETP and EDC (electrodeposited copper) at 10GHz.

The Q of the OFC resonator turned out to be just on 14% higher than those made from ETP and EDC, even though the 'DC' resistance of the OFC he had used was only 0.7% lower than that of the ETP and EDC.

As all other factors seemed to be the same, Mr Kamada deduced that the much greater Q produced by using OFC must be due to its lower internal 'intergrain' capacitance. And although this experiment was carried out at a microwave frequency, he decided that it supported his theory about the effects at audio frequencies.

His next step was to consider whether simply changing to OFC was in itself enough. Would it be possible to achieve even more of an improvement?

Even though OFC had 100 times less Cu_2O at the grain boundaries, it obviously still *had* grain boundaries. And a grain boundary itself is an area of imperfection in the crystal lattice, with missing molecules and so on.

Mr Kamada reasoned that the missing molecules would make the grain boundaries act as tiny 'gaps' in the copper, each of which would again act like a tiny capacitor with a vacuum as its dielectric. So even though OFC had very much less Cu_2O than normal ETP copper, it would still tend to behave electrically rather like Fig.2 (but without the diodes) – simply by virtue of having grain boundaries in the copper.

This suggested that it might be possible to achieve even better performance than had already been achieved using OFC, by increasing the size of the copper grains and hence reducing the number of grains (and grain boundaries) per unit length.

To test this theory, Mr Kamada tried another experiment – and one which should bring a smile to the face of at least some of our readers.

Remember our tongue-in-cheek story in the April issue, about the 'ultimate' speaker cable – using mercury-filled plastic hoses?

Well, believe it or not that's exactly what Mr Kamada used, to try the effect of using a cable with conductors having no grain boundaries at all. He used mercury because it's a liquid, and as a result the only metal currently available – apart from lead – in a form which lacks any grain boundaries.

(And we thought the whole idea was so way-out and impractical that it made a good April fool's joke!)

Using the mercury cables, Mr

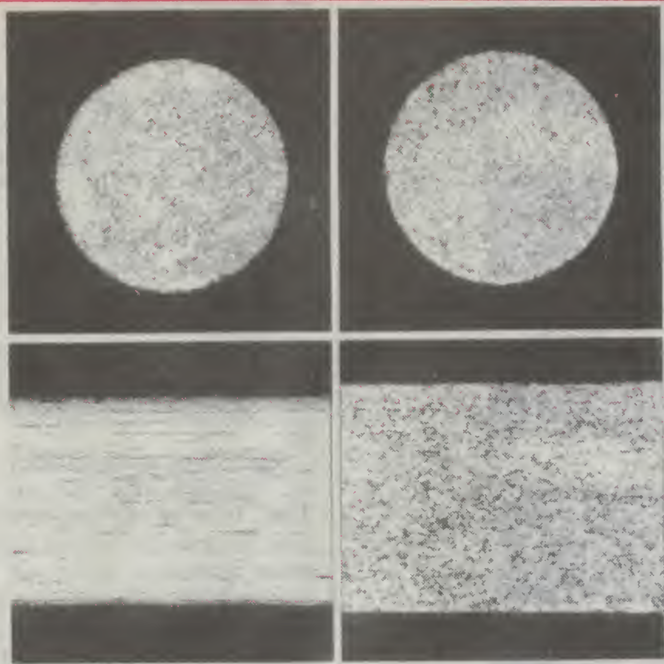

Fig.3: Microscopic photographs (x200) of Hitachi's LC-OFC (left) and ordinary OFC (right), showing the different crystal structure.

Kamada carried out A-B tests with two groups of top hi-fi critics and audio design engineers in Japan. The overwhelming consensus of opinion was that the mercury cables gave superb sound, much more 'real' and 'transparent' than cables made from even OFC or silver – let alone conventional ETP copper. And this despite the fact that mercury has a DC resistivity over 40 times that of even ETP copper, and over 50 times that of silver!

Needless to say, Mr Kamada was very encouraged by this result, which suggested that grain boundaries in copper (and presumably other crystalline metals) might indeed be a subtle cause of electrical distortion. Even though he still couldn't actually come up with any *objective measurements* which would quantify the perceived difference between the mercury and conventional cables – let alone between OFC and ETP cables...

The next step was to see if he could increase the grain size in OFC, so it would have fewer grains and boundaries per unit length.

The average grain size in OFC was already about 3 times that of ETP copper – around 20um compared with about 7um. Not a dramatic difference, but presumably worthwhile; there were only about 50,000 grains per metre length, instead of about 150,000. Presumably this was because the lower Cu_2O content allowed the crystals to grow larger.

Mr Kamada tried to make the grains grow even larger, by using a technique called 'super-annealing'. This involves holding the copper for long periods at a temperature just below its melting point, in an inert gas environment.

The results were again very encouraging. Average grain size grew to around 500um (0.5mm) – an improvement of 25 times over ordinary OFC and corresponding to only 2000 grains per metre. Measurements of this 'giant-crystal OFC' or GC-OFC, in microstripline resonators at 10GHz showed a further 3% increase in Q, and audio cables made from GC-OFC were ranked even higher than ordinary OFC cables in subjective tests.

Could the grain size be increased still further? It appeared not. But all was not lost; he realised that the really important parameter in this context was not overall grain size as such, only the *length* of the grains in the direction parallel to the wire's main axis. So he hit on the idea of drawing the wire down to a smaller size, by a ratio of 10:1. This stretched the crystals out in the direction of the wire's axis, increasing their length by about 100 times – to an impressive 50mm long.

They became a lot thinner in the process, of course, but this could be overcome by using many such wires in parallel to achieve the desired cross-sectional area. And the average number of grains/grain boundaries per metre with this 'Linear Crystal OFC' or LC-OFC cable had dropped to about 20 – an improvement of about 7500 times compared with ordinary ETP copper cables.

Fig.3 shows microscopic photographs comparing the structure of ordinary OFC wire 180um in diameter with that of LC-OFC wire of the same diameter. The elongated crystals are quite apparent in the latter, particularly in the lower view along the axis.

Apparently the subjective results in audio tests comparing this LC-OFC cable with those using both ETP copper and ordinary OFC are quite impressive. Those who have heard them describe the difference as 'very obvious', with claims that the LC-OFC cable gives much greater 'transparency', 'sharper transients', 'wider dynamic range' and so on.

There doesn't seem to be much doubt that Mr Kamada is onto *something*, then. Or that his improved 'LC-OFC' cables do provide at least a subjective improvement in audio quality. Perhaps he and Hitachi Cable are right in claiming that LC-OFC would provide even more of an improvement in audio and video systems, if it were used throughout the signal path – not just for the speaker cables.

But I still find it puzzling that even Mr Kamada, for all his ingenuity, hasn't been able to come up with a single objective test which *measures* the improvement provided by LC-OFC or even ordinary OFC, at audio frequencies.

Of course the reason for this might well be that as yet, we simply don't have measuring instruments and techniques which are as sensitive as the human ear in detecting subtle forms of frequency and phase distortion. This kind of limitation in measurement technology has certainly happened in the past.

Unfortunately in this kind of situation there's always the alternative possibility: in the absence of objective measurements, it's easy for we humans to fool ourselves into hearing what we want to hear, or what we think we should be hearing.

There was a very interesting and thought-provoking article on this effect in the July 1988 issue of the UK magazine *Electronics and Wireless World*, written by a chap called Douglas Self and entitled 'Science vs Subjectivism in Audio Engineering'.

It's hard to tell whether Mr Kamada's tests with various kinds of cable could have allowed this kind of error to creep in. I can't find any reference to 'double blind' testing, where neither the subjects nor the experimenter knows the exact test conditions at any instant dur-

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ing the actual testing, and can't therefore fool themselves. But Mr Kamada seems a pretty methodical kind of worker, so presumably he did take this kind of precaution.

If so, his A-B comparative tests would be objective at least to the extent of showing that cables of OFC and especially LC-OFC do improve audio quality, in a way that is discernable to humans. It's just a pity that there aren't any measurements as yet to back this up.

Apart from anything else, it seems to me that this must cast at least some doubt over Mr Kamada's theory about grain boundaries causing frequency and phase distortion, due to all those little capacitors across the gaps. If that were so, you'd think we'd be able to *measure* this distortion, wouldn't you?

It's all very puzzling, to be sure.

Another thing that occurs to me is that even if Mr Kamada is right with his theory about the importance of grain boundaries, this in itself mightn't be much of an argument for OFC as such. Perhaps the only real advantage of OFC is that it can be made to grow into larger grains than ETP copper – not the fact that it contains less oxygen.

It seems to me that the whole business of oxygen content and Cu_2O at the grain boundaries might yet turn out to be a complete phurphy, after all. If a way could be found to make ordinary ETP copper form large crystal grains, or even make it grow into single crystals, perhaps this would achieve just as big an improvement.

Just before we leave the subject, at least for the moment, a final thought: if Mr Kamada is right, and the grain boundary around each crystal is essentially a vacuum gap, how is it that a copper wire is able to conduct DC?

When you think about it, even his you-beaut LC-OFC copper wire with its grains 50mm long is still composed of a finite number of grains, supposedly linked only by the capacitance across each of their boundaries. And since capacitors only pass AC, this suggests that even an LC-OFC cable should be an open circuit for DC. Not just a high resistance, but a true open circuit!

Obviously this isn't so. Even wires made from ordinary ETP copper conduct DC exceptionally well.

Which again seems to throw a certain amount of doubt on Mr Kamada's theory, don't you think?

See you again next month.

The Electronics Australia - Dick Smith Electronics

GRAND AUSSIE HOBBY ELECTRONICS CONTEST - THE WINNERS

Here it is at last: the news for which quite a few of our readers have been waiting, with anxious anticipation. Obviously a lot of readers liked the idea of our Grand Aussie Hobby Electronics Contest, because there was an excellent response. The judges had a hard job, wading through so many well-prepared entries!

Our motivation in running the contest, you might recall, was basically to try and re-kindle interest and enthusiasm in electronics as a hobby. Judging by the number of entries we received, it certainly seems to have made quite a good start in this direction. Hopefully this will build and grow, as we publish the winning designs (and many of the other entries) over the next few months.

Just before we announce the winners and give brief details of their entries, there are a few general comments we'd like to make about the entries as a whole.

The first is that overall, we were most impressed with the high standard of the entries, and the amount of effort that had obviously gone into them. This didn't apply to every single entry, to be sure; but it certainly did to most of them.

The majority of entries not only showed evidence of a great deal of effort having been expended on the design and development of the project itself, but on its presentation as well.

We were also impressed by the number of entrants who had fairly obviously used a word processor to prepare their article describing the project, and a CAD system to prepare artwork items such as their PCB pattern. It's nice to see how many *EA* readers are using modern hi-tech aids!

Finally, we were very impressed by the innovation and elegance evident in many of the designs – particularly those that won prizes. So many of the entrants had obviously gone 'back to basics', and put considerable effort into arriving at the simplest, most economical and easiest to build design able to do the job required.

All in all, then, the entries to the contest were impressive not only impressive by their number, but by their generally high quality. Both of which seem to us to augur well for the future of Australian electronics – both as a hobby vocation and as an industry.

But enough of the preamble. Let's get down to the nitty-gritty – who did win, and what were their winning designs?

The Newcomer section winners

The winner of **First Prize** in the Newcomer section was Mr Peter Boyle, of 194 Station Street, Edithvale Victoria. Mr Boyle's entry was a design for a Brake Lamp Monitor for cars, which continuously checks the brake lamp circuits for burnt-out lamps and other kinds of fault, and alerts the driver immediately in the event of trouble.

Mr Boyle's design is quite clever in that the existing brake lamp circuit doesn't have to be broken. It also uses parts worth only around $20 and is compatible with almost any car and car-trailer combination. It seems likely to have wide appeal, contributing as it does to motoring safety. It was for all of these reasons that the Judges voted it the winner in this category.

Mr Boyle's prize is a collection of test instruments and tools from DSE worth over $1100, plus a DSE Components Voucher worth $400 – a total prize of over $1500.

The runners-up in this category were Mr John Thomson, of 40 Upper Dawson Road, Rockhampton Queensland, and Mr David Adkins of 157 Doncaster Avenue, Kensington NSW.

Mr Thomson's entry was another automotive project – an Interior Light Delay Unit, which keeps a car's interior light on for a preset time after the doors are shut. It also dims the light to allow map reading, etc., without distracting the driver.

Mr Adkins' entry was a Digital Distance Measuring Unit – rather like a digital 'tape measure', and capable of measuring distances up to 10 metres with a high degree of accuracy.

Both designs were elegant, used commonly available parts and again seemed likely to appeal to large numbers of people. The Judges decided that they were a little better in these respects than the remaining entries, and thus awarded John Thomson and David Adkins with the runner-up prizes of DSE Components Vouchers worth $100 each.

The Judges did however award a special commendation to Mr Bruce Farnell, of 41 Taylor Street, Eaglehawk Victoria, for his entry of a PC-based Logic Controller. Although judged a little limited in its appeal, Mr Farnell's project was beautifully presented and he had obviously spent a great deal of effort on it.

The Advanced section winners

The winner of **First Prize** in the Advanced section was Mr Wen Liang Soong, of 16 Cremorne Street, Fullarton South Australia. Mr Soong's entry was an Audible Continuity Tester called 'Beepo', featuring three different tones, the ability to operate over 6 decades of circuit resistance, and auto polarity reversal – all neatly housed in a tiny pocket-sized Jiffy box.

Using a handful of readily available parts worth a total of about $35, and with a particularly ingenious design, Beepo was judged a most useful and appealing little tester. Although the competition in this section was very fierce, the Judges decided that Beepo had a slight edge over the others.

Mr Soong's prize is a package of a 20MHz Dual Trace Oscilloscope, a Digital Multimeter and a 'Pro' Soldering Station together worth over $1300, plus a DSE Components Voucher worth $250 – a total prize value of over $1600.

The runners-up in this section were Mr Paul Thompson, of 2/25 Oliver Street, Wooloowin Queensland, and Mr Tony Agius, of 6 Kiama Street, Redwood Park SA.

Mr Thompson's entry was an Electronic Metronome with the novel name

(Continued on page 137)

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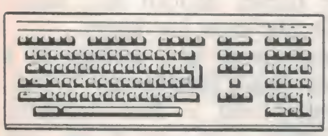

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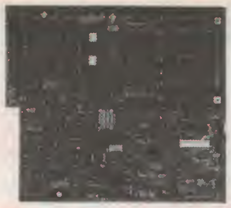

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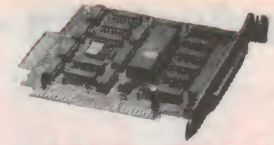
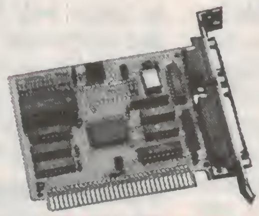


FLOPPY DISK DRIVE CONTROLLER CARD
These cards will control up to 2 or 4 double sided 360K IBM* compatible disk drives.

X18005 (2 Drives)...**$52**

FLOPPY DISK DRIVE CONTROLLER CARD
- Supports 1·44MB, 1·2MB, 720K, 360K
- PC*/XT*/AT* compatible
- 5¼" and 3½" drives

X18009 .... **$139**



GRAPHICS CARD
- Hercules compatible
- Interface to TTL monochrome monitor
- One Centronics parallel printer port
- 2K-Static RAM, 64K Dynamic RAM
- Display Mode: 720 dots x 348 lines

Cat. X18003 ...... **$139**

COLOUR GRAPHICS CARD
This card plugs staight into I/O slot and gives RGB or composite video in monochrome to a monitor.
Colour graphics: 320 dots x 200 lines.
Mono graphics: 640 dots x 200 lines.

Cat. X18002 .... **$99**

ENHANCED GRAPHICS ADAPTOR CARD
- 256K display RAM
- Handles monochrome, CGA Hercules and E.G.A.
- Paradise* compatible
- Up to 16 colours
- Standards: 320 x 200, 640 x 200, 640 x 348, and 720 x 348.

X18070 .... **$330**

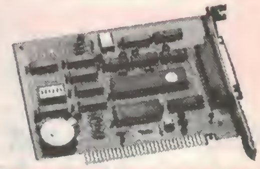
COLOUR GRAPHICS & PRINTER CARD
This combination card features printer and monitor interface. It has 1 parallel printer port, RGB CTTC outputs.
Colour:
Text Mode: 40 columns x 25 rows.
Graphics: 320 x 200
Monochrome:
Text Mode: 80 columns x 25 rows.
Graphics: 640 x 200

Cat. X18010 .... **$99**

PRINTER CARD
This card features a parallel interface for Centronics printers. Included is printer data port, printer control port, and printer status port.

Cat. X18017 .... **$29**

HARD DISK CONTROLLER CARDS
X18060 (XT) **$190**
X18140 (AT) **$290**



RS232 & CLOCK CARD
(WITHOUT CABLE)
This RS232 card supports 2 asynchronous communication ports. Programmable baud rate generator allows operation from 50 baud to 9600 baud. Fully buffered. Clock includes battery back-up and software.

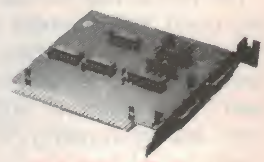
Cat. X18028 .... **$89**

RS232 (SERIAL) CARD
(WITHOUT CABLE)
This RS232 card supports 2 asynchronous communication ports. Programmable baud rate generator allows operation from 50 baud to 9600 baud. Fully buffered. First serial port is configured as Comm.1 Second serial port is optional and configured as Comm.2.

Cat. X18026 .... **$49**

CLOCK CARD
Complete clock card including battery back-up and software.

Cat. X18024 .... **$55**

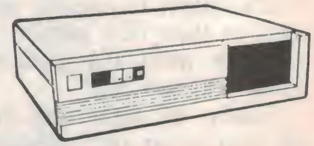


GAMES I/O CARD
Features two joystick ports. (DB15).

Cat. X18019 .... **$29**

I/O PLUS CARD
Provides a serial port, a parallel port and a joystick port, and even a clock/calendar with battery backup!

Cat. X18045 ..... **$119**



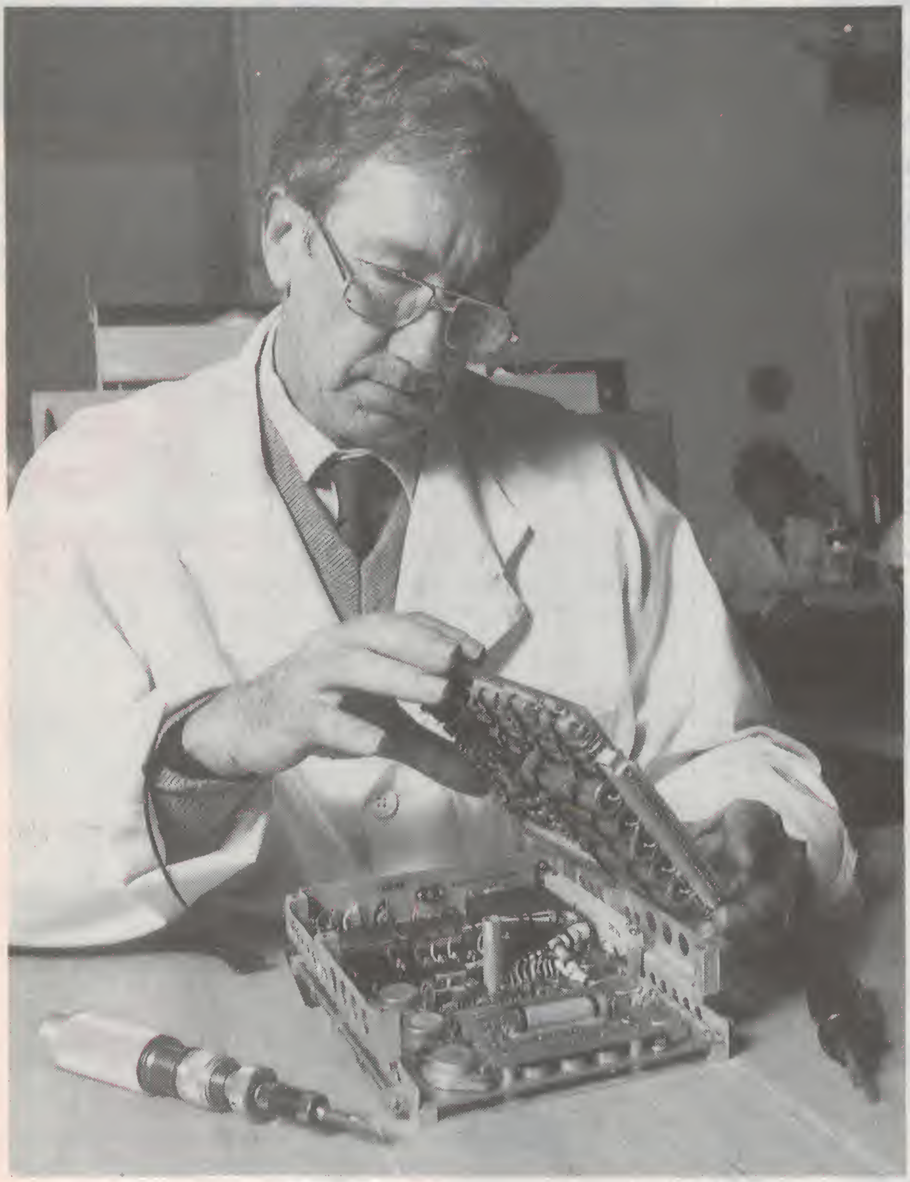
IBM* XT* COMPATIBLE CASE AT* STYLING
Now you can have the latest AT* styling in a XT* size case. Features security key switch, 8 slots, and mounting accessories.
Size: 490(W) x 145(H) x 400(D)

Cat. X11091 .... **$99**

BABY AT* STYLE COMPUTER CASING
Our latest computer casing, featuring security key switch, 8 slots, and mounting accessories etc.
Size: 360(W) x 175(H) x 405(D)

Cat.X11093 **ONLY $99**

News Highlights



F/A-18 contract

Alcatel-STC, Australia's largest telecommunications manufacturer, has won a fourth contract with General Electric Aerospace, New York, to produce a further 525 power supplies to drive the flight control computers on the F/A-18 Hornet. The F/A-18 is at the forefront of our air strength, and power supplies assembled and tested by Alcatel-STC will be used on the Australian version of the aircraft, as well as on those made for Canada and Spain.

The power supplies are switch-mode with multiple outputs, ranging up to 28 volts in DC and averaging around 8 volts in AC. They are powered by batteries which are charged by the F404 jet engines. Each Hornet uses four of these units in a fault tolerant configuration – if there is damage or failure to one power supply, another will take over its load and keep the flight control computers running.

Amateur radio

All amateur radio operators, or those interested in amateur radio are invited to attend the 1989 Gosford Field Day to be held on Sunday, 19th February 1989 at the Gosford Showground. Gates will open at 8am wet or dry as all displays are under cover.

Hi-fi designer

A man widely regarded as one of the leading designers of the modern high-fidelity era visited Australia in October to discuss future trends in hi-fi. He is Mr Ken Ishiwata, product manager and chief designer of Marantz International, based in Eindhoven in The Netherlands.

Ken Ishiwata began his working life with Pioneer, who first sent him to Europe in 1968. He joined Marantz ten years ago, and as international product manager has played a key role in that company's change in corporate direction in recent years.

Mr Ishiwata has been closely associated with the design of the award-winning PM94 and PM64II integrated amplifiers, and has overseen production of Marantz's two-piece CD94/CDA94 combination CD player and digital-to-analog converter.

Hobbyist group for WA

The Perth Information Technology Centre (ITeC) has determined that there is sufficient demand for an Electronics Hobbyist group in Perth, and is therefore interested in starting such a group. The ITeC would provide a venue where enthusiasts could meet, have access to workshop and test equipment facilities and generally swap ideas.

The Perth ITeC already has an active computer user group with facilities open several times per week and on the weekend. If an electronics group were formed, it would be able to use the existing workshop facilities on an as required basis.

Further enquiries can be directed to Terry Dawson, 188 Adelaide Terrace, Perth, 6001 or phone (09) 325 8544.

AUSSAT expands across the Tasman

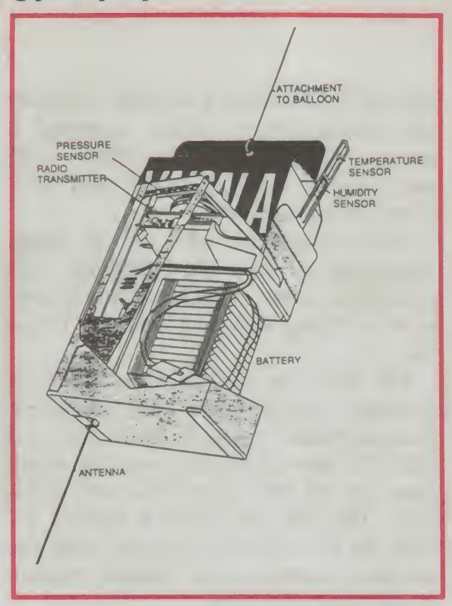
AUSSAT has announced major expansion plans for the development of satellite based telecommunication services across the Tasman, that includes the construction of a satellite transmit and receive earth station in New Zealand.

The earth station, estimated to cost $2 million, will be located on the top of a major building development in the heart of Auckland's central business district. Construction of the facility will commence within the next few months and once completed will provide 'gateway' access to the AUSSAT satellite system for Trans Tasman telecommunication and broadcasting users.

$4.12m for new Meteorology equipment

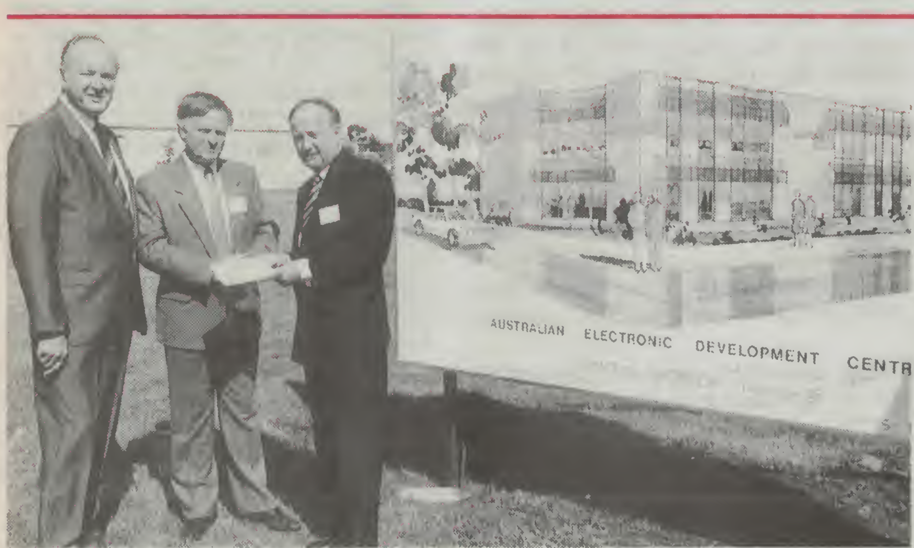
The Bureau of Meteorology is to acquire a $4.12 million system to obtain vital atmospheric data. The Director of Meterology, Dr John Zillman, announced that the system is for use at the 32 observing stations that comprise the Bureau's Australia-wide 'radiosonde' network.

The new equipment will include a two-year supply of modern, lightweight radiosondes; which are balloon-borne instrumented packages that transmit measurements of temperature, pressure and relative humidity back to ground stations every few seconds, up to altitudes of 30km. As well, ground-based equipment, including microcomputers, for the processing and onward transmission of weather information is being purchased.



Dr Zillman said a contract for provision of the new system has been awarded to Vaisala Pty Ltd, an Australian subsidiary of the Finnish firm Vaisala Oy. The contract has been arranged by the purchasing and sales group of the Department of Administrative Services. The contract also provides for additional expenditure of up to $11.7 million over the next ten years for further equipment, at the Bureau's option.

The new system is expected to be operating in the Bureau's upper air observing stations by early 1990. Its introduction will be an important milestone in the Bureau's accelerated re-equipment program announced by the minister responsible for the Bureau, the Minister for Administrative Services, Mr Stewart West, as part of the 1987-88 budget.



The Minister for Industry, Technology and Resources, Mr Fordham (right) hands over a cheque for $1 million to Mr Trevor Barr (centre) to mark the Victorian Government's contribution to the start of the Australian Electronic Development Centre.

Electronics Centre

Ericsson will be the principal sponsor of the $3 million Australian Electronics Development Centre. The centre is the first of its type in Australia and is designed to lift Australia's electronics and telecommunications industry to international standards.

During the opening ceremony to mark the launch of the project, Mr Fordham, the Minister for Industry, Technology and Resources, announced $1 million of funding support for the centre. The centre will be established within the Broadmeadows grounds of L.M.Ericsson, the principal sponsor of the facility. Ericsson was the prime instigator of the centre and has made a significant commitment to its success. The company's contribution to the centre, at this stage, is more than $1 million.

Drug free Olympics

The Seoul Olympic doping-control laboratory used equipment supplied by Hewlett-Packard to help keep the 1988 Olympic Games drug free.

During the two-week period of the Games, the equipment operated 24 hours a day, handling as many as 200 samples daily. All medal winners, fourth place finishers and randomly selected athletes were tested. In all, 6000 analyses were run on a total of 2000 samples.

HP had been training Korean technicians in the use of this equipment for more than three years, both in Korea and in the United States.

Dr Jong-Sei Park, technical director of the Olympic Games Doping Control Centre, examines a chromato graphic analysis from an HP 5890 gas chromatograph from the Hewlett-Packard Company.

News Highlights

Top companies

A new survey of leading electronics companies places Norsk Data of Norway at the head of the world profitability league. The Elsevier-BEP publication, World Electronics Companies File, produces an annual table of the performance of the top 150 electronics/IT corporations based in 30 countries.

Norsk Data, with a profit before tax ratio of 18.4% of sales turnover, were the most profitable company with a product range 100% concentrated on the electronics/IT industry; only two other companies, Hyundai of South Korea and the Rank Organisation of the UK, had a better profitability ratio, but only a small percentage of their respective sales are in the electronics/IT sector.

Norsk Data were followed in the table by three other major computer manufacturers, DEC, IBM and Apple, each recording a profit before tax/sales ratio over 16%. The least profitable company was Schlumberger, which recorded a near 42% loss in 1986 with electronics/IT accounting for only 39% of total sales turnover.

Other companies with pre-tax losses amounting to more than 20% of turnover were Scitex of Israel, Conic Investment of Hong Kong and Mitel of Canada.

The File Top 150 Table is based on company performance for complete financial years ending between 9/86 and 8/87, the latest complete year for which data for all the companies was available. The Top 150 Table is ranked initially by size of sales turnover, with the minimum qualification US$100 million in electronics/IT sales.

The largest national group represented is the USA, with 53 of the world's top 150 electronics/IT companies American-owned. Japan follows, with 24 companies in the top 150, while the largest European nations are the UK, 13 companies; West Germany, 12 companies and France, with 11 companies. Companies from a total of 30 countries are represented and are estimated to account for over 75% of the world's electronics/IT product sales.

Collectively, the Japanese companies have the highest labour productivity, as measured by sales per employee, with $184 thousand in sales per worker; USA productivity is $99 thousand per worker, West German $83 thousand per worker, French $76 thousand per worker, with the British trailing the other major countries at an average of $55 thousand worth of sales per worker – a figure matched by Apple Computer, which earnt $55 thousand per employee in pre-tax profits alone; the average sales per employee for the top 150 companies in total was $98 thousand.

The lowest sales per employee ratio was recorded by Baharat Electronics of India, at $12.5 thousand, followed by Conic Investment of Hong Kong at $20 thousand and BET of the UK at $28 thousand, although only 14% of BET's turnover is accounted for by electronics products.

The largest investors in research were Lockheed, who devoted over 31% of sales turnover to R&D expenditure (58% of group sales accounted for by electronics/IT), Advanced Micro Devices, who spent 27.7% of turnover on R&D and TRW, 27% on R&D (53% of sales accounted for by electronics/IT); a number of leading British electronics groups still fail to publish an indication of expenditure in this all-important area.

News Briefs

- IC socket manufacturer ***Augat*** have recently set up a joint manufacturing facility in Singapore, and are now well poised to fulfil a plan to significantly increase their presence in Australia and New Zealand.
- A change of address has been announced by ***Hard Copy***, a technical writing company. The new address is Suite 105, 159 Kent Street, Sydney 2000, and the new phone number is (02) 27 3437.
- ***Emulex Corp*** and ***Webster Computer Corp*** have announced a co-operative marketing, sales and service agreement. Both companies are involved in the DEC compatible computer marketplace.
- Mr Takeshi (Ted) Shibazaki has been appointed general manager of ***TDK***, replacing Mr Ken Kihara who has since returned to Japan. The new appointment coincides with TDK's recent move to St Leonards from its previous Pyrmont address.
- ***Amber Technology*** has moved its Melbourne office to new and larger premises on 200 Rouse Street, Port Melbourne, 3207. The new phone number is (03) 646 5811.
- A number of new appointments were recently announced by enhancement board builder ***Hypertec***. Philippa Stewart has been appointed marketing manager, David Evans becomes commercial director and Bishu Bojdak is the new financial controller. As well, Andrew Carroll and Andrew Farkas have joined Hypertec as senior sales representative and software engineer respectively.
- Ex AWA dealer support manager Jim Barnes has joined ***Zenith Data Systems*** as dealer development and support specialist.
- The Manhattan based software producer, FORTH,Inc., has announced that ***Energy Control International*** of Brisbane will be its primary representative in Australia and New Zealand.
- ***Trace Technology*** has announced the relocation of its Melbourne headquarters to 200 Rouse Street, Port Melbourne, 3207. The new phone number is (03) 646 5833.
- The Australian distributor for Conceptronic, a leader in the surface mounted component field, is ***Royston Electronics*** at Unit 2, 28 Vore Street, Silverwater, 2141, phone (02) 647 1533.
- Bob Goss has been appointed customer service manager – telecommunications, for the newly opened Adelaide branch office of ***Siemens***. The address of the new office is 297 Pirie Street, Adelaide.

Telelearning

The Optel Telewriter system, well established in the US, is now available in Australia and New Zealand from Olivetti Australia Pty Ltd. Since its introduction a few months ago, the NSW Education Department has purchased ten systems for use in a pilot scheme of remote interactive teaching.

There are many different uses for the Telewriter system, which is personal computer based and uses voice, graphics and colour video images over a single telephone line.

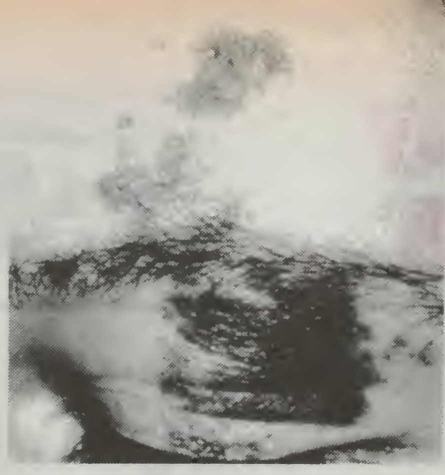
The Telewriter system is used for not only telelearning, but telemedicine, teleconferencing and teletraining, depending on the user's application. This is due to its ability to provide all the resources to the remote users, as if they were in the same room.

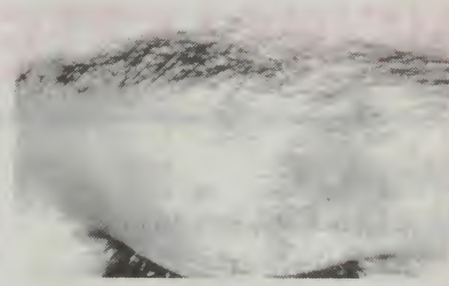
Lasers that heal

Lasers that can take the shell off an egg yet leave untouched the fragile membrane beneath, or burst an inflated party balloon inside another balloon without breaking the outer's skin, are now being used for the first time in Australia to harmlessly crumble kidney stones and virtually eliminate disfiguring birthmarks without scarring.

The Candela SPTL-1 dermatological laser and Lasertripter for treatment of kidney stones represent all-new technology introduced to Australia by Solus Medical Imaging, a division of Hanimex.

Both lasers use technology called flashlamp-excited, tunable dye lasing. Such lasers can be adjusted, or tuned, so that they zap a precise target area without affecting adjacent tissue. The SPTL-1 is currently being tested by skin specialists at Sydney's Royal Prince Alfred Hospital dermatology unit.





The $400,000 Candela Lasertripter is a technological breakthrough that offers urologists a safe and effective method of fragmenting kidney stones without affecting in any way delicate ureteral tissue. Hospitalisation is reduced from weeks in some cases to a few days or less.

Aussie export

A major export breakthrough has been achieved by Australian owned Megadata with the announcement that the company has been awarded a contract to provide a $A6 million high tech monitoring and control system for the Manila Electric Company (MERALCO).

"This is the first time an Australian owned company has successfully competed overseas against the major international suppliers in the SCADA field," said Mr Julian Dinsdale, managing director for Megadata.

Finance was arranged through Austrade's Export and Finance Insurance (EFIC) and the Australian International Development Assistance Bureau (AIDAB).

Megadata was a winner of the High Tech Exporters Scheme Award for 1987/88 made by the Australian Trade Commission last year.

Fluke with Philips

The Test and Measurement alliance of Fluke and Philips was formally launched into Australia and New Zealand on October 1, 1988. This follows similar alliances in other parts of the world.

Tim Wortman, manager of the Test and Measurement group of Philips Scientific and Industrial Pty. Limited, heads the team responsible for the marketing of Fluke and Philips products in Australia and New Zealand. The Australasian head office for Philips Test and Measurement recently moved into larger premises within the centre court complex at 25 Paul Street North, North Ryde. Sales and support facilities have therefore been upgraded without the problem of changing the address or the phone number. In Victoria, Philips Test and Measurement is now in the Philips complex at the new Tally Ho Technology Part at Burwood East.

CTV system

Integral Fibre Systems (IFS), has announced it has made significant progress towards the development of a prototype multichannel video system for which it received a $200,000 grant from the Australian Government Industrial Research and Development Authority.

The IFS video system is designed to provide a high quality cost effective alternative to current systems being used in medium haul, up to 50km CTV applications. The company initially won the grant on the basis that the technology is new to Australia, of a high standard having significant cost benefits over similar systems produced elsewhere.

The system has been designed so that while normally carrying standard colour signals it can be easily adapted to carry widerband width signals. The basic system has been developed to meet further market demands as they arise, including transmission of other signals such as telephone, facsimile etc. as may be required by the fibre optic subscriber system of the 1990's.

AWA micros

Commissioning is well under way at AWA MicroElectronics' new $65 million Homebush Bay facility. Advanced equipment worth some $30 million has already been installed. When fully commissioned the plant will be the only one in Australia capable of offering a complete one-stop design and manufacturing service for state-of-the-art ASICs (Application Specific Integrated Circuits). The Australian market for these high performance and cost effective chips is growing at about 40% annually.

One of the key features of the Homebush Bay facility is its extremely efficient clean room in which key manufacturing processes take place in conditions far cleaner than the most sterile operating theatre. Tests show that the AWA clean room permits only one particle of 0.1 micron size (about the size of a virus) per cubic foot of air. This is better than the plant's specification and puts the clean room high on the list of the most efficient in the world.

AWA's massive investment in Homebush Bay represents the biggest single outlay by the company since its restructuring earlier this year. The first commercial silicon will come off the production line before the end of this year.

Silicon Valley NEWSLETTER . . .

Cal Micro hits the big league

California Micro Devices may have found a way to buck the corporate food chain. Rather than growing by swallowing smaller companies, the little Milpitas semiconductor company seems to be thriving by gulping down companies several times its size.

Last month Cal Micro closed a $70 million deal to buy a company three times its size: Gould's American Microsystems Inc. in Pocatello, Idaho.

Cal Micro got a bargain, analysts say. AMI's advanced chip fabrication facility alone is worth more than the price tag. And the deal will catapult Cal Micro's sales, which just a year ago were $10 million, to about $130 million – making it the nation's fifth-largest customized chip firm and a formidable player in the burgeoning field.

Chen Desaigouder from Cal Micro has spent $70 million buying AMI.

But such growth has not been without risk, observers say. The $30 million company is borrowing more than twice its annual sales to finance the deal.

A 68030 Macintosh

In an apparent pre-emptive strike against Steve Jobs and his NeXT computer, Apple have introduced the industry's first personal computer built around the powerful Motorola 68030 microprocessor.

The move comes just three weeks before NeXT is scheduled to launch its long-awaited computer which is also expected to be built around the 68030. The move also contradicts earlier statements from Apple president John Sculley that the Cupertino firm would not introduce any major new products until the next fiscal year which starts in October.

The new Apple computer will be known as the Macintosh 11x. Unlike the NeXT system, the 11x does not take full advantage of the power of the 68030, as the new system operates only about 10-15 percent faster than the 68020 based Macintosh 11.

One key feature of the new machine is its 3.5-inch floppy disk drive that will be able to read both Macintosh software, as well as programs and data disks for the Apple 11 and IBM PC & PS/2-type computers. "The drive is the most significant part of the announcement", commented Jack Kolk, vice president of a Macintosh product distribution company in Sunnyvale.

National in two disputes

National Semiconductor disclosed it is embroiled in two legal disputes that could cost the Santa Clara chip maker close to $75 million.

The potentially largest dispute involves a claim filed against National in April by the U.S. Customs Service which claims the company owes the government some $19 million for underpaying duties on imported components between 1979 and 1985. Under the government's rules, National could face penalties amounting to several times the alleged underpayment.

In the second dispute, National has filed a lawsuit against Schlumberger in which it is seeking to avoid having to pay an additional $15 million to Schlumberger for the purchase of Fairchild Semiconductor.

Space plane

American scientists believe they have made great progress in the past year on the development of a revolutionary space plane. Some even believe the goal of getting a prototype of the aircraft ready for test flights in 1994 appears well within reach.

"We are halfway there theoretically," according to Robert Barthelemy, who is director of the federally funded National Aero-space Plane Program. According to Barthelemy, in another two years, the development should be far enough to determine exactly what the new plane's range of capabilities will be in terms of commercial, military and transport applications, and what it will look like.

Preliminary studies are calling for an aircraft that will be about the size of a Boeing 727, take off horizontally from commercial airports, and travel at about 17,000 miles per hour once it has reached its cruising height. The U.S. plane, under the project name X-30 is likely to be radically different from other space planes under consideration in Great Britain and elsewhere. For one, the U.S. team has settled on a single-stage craft concept.

The U.S. plans call for a prototype ready to be test-flown by October 1994.

Motorola in China

If rumors pan out, Motorola is about to announce plans to build a massive $300 million semiconductor manufacturing plant in the People's Republic of China. It would be the first U.S. chip manufacturing plant in this country.

It would also give a tremendous boost to that country's renewed efforts to improve its domestic chip making capabilities. As part of the new program, Chinese government officials invited representatives from the Semiconductor Industry Association to their country earlier this year to discuss the possibility of increasing U.S. interests in the Chinese market. It's not known whether the Motorola plans are a direct result of those discussions.

Warren Davis, vice president of the SIA, said that in addition to Motorola,

Intel and Texas Instruments are also negotiating with the Chinese government about setting up chip facilities in their country. "It is quite obvious that China is a huge opportunity for the future. Ten years from now, I'm sure there will be many U.S. companies manufacturing there."

Cypress under siege

For the third time in as many weeks, Cypress Semiconductor has been sued by one of America's largest semiconductor manufacturers. And like the other two, Motorola has accused the San Jose company of stealing some of its trade secrets.

Motorola claims Cypress conspired with one of its top RISC chip designers to steal critical Motorola technology.

Last month, Roger Moss, (designer of Motorola's recently introduced 88000 RISC processors) and five key members of the 88000 development team unexpectedly resigned. They immediately formed Ross Technology in Austin, Texas. Financial backing for Ross Technology has been provided by Cypress which gave the group an initial $100,000 loan to set up shop and is likely to provide several million dollars more in venture capital. Cypress appears interested in establishing Ross Technology as its microprocessor development affiliate.

Speculation rife about NeXT

Although Steve Jobs may have formally announced a date for the launch of his NeXT computer, the guessing game surrounding NeXT continues unabated. But rather than speculating about an introduction date, the emphasis has shifted towards the system's expected features and its sales price.

Educators would like to see a price of around $1000. But even with the 30-40 percent discounts Jobs is likely to offer students, that price range is almost inconceivable.

The best guess at this time is that the price will be in the $4500 to $5700 range. In part, this estimate is based on some statements Jobs made during a speech this week at the Seybolt Desktop Publishing Conference. Jobs said that both Unix operating system and the Adobe Systems Display Postscript software that he will use for his NeXT computer each require an additional megabyte of memory and add about $1000 each to the cost of the machine. "It's about a $2000 price increase to get aboard the 1990s." Jobs said.

Commented Stewart Alsop: "Basically he is saying you will be paying for the right to get all these goodies."

As far as physical description, the latest rumors talk about a black cube, although some believe these rumors may refer to disguised prototypes shown to certain key analysts and potential customers.

Overcoming the DRAM shortage

In a desperate effort to undo the stronghold Japanese DRAM chip makers currently have on the U.S. computer industry, a number of major American computer and semiconductor companies are reportedly close to announcing as many as three separate joint ventures aimed at resurrecting a U.S. DRAM industry.

Although rumours about U.S. joint DRAM ventures have been circulating in the U.S. for months, the announcement of the first of these co-operative efforts between computer and chip makers may be only a few weeks away. The first confirmation that discussions for a DRAM joint venture are taking place has come from Motorola which said it is considering setting up a second DRAM facility in addition to the one it is currently building.

Industry observers say that some of the most likely partners in any of the rumored DRAM ventures will be Apple Computer, Sun Microsystems, and Compaq, all of who have suffered from the shortage of DRAMs forcing them to raise prices and delay product shipments.

Challenge to IBM bus

In perhaps the biggest blow to IBM's efforts to regain leadership in the personal computer market with its new PS/2 line, a number of IBM's largest rivals in the PC market are expected to announce the formation of a consortium that will develop a rival bus architecture to IBM's new MicroChannel bus.

The group supporting the effort will include Compaq, Hewlett-Packard, Wyse Technology, Tandy, AST Research, Epson, NEC, Olivetti, and Zenith Data Systems. Reportedly Intel and Microsoft have also agreed to play a key role in the effort to develop the new bus.

It is the second time this year that a consortium of companies have joined forces to derail the efforts by a market leader to set a new industry standard. Earlier, the Open System Foundation group of firms split the Unix market in half by trying to develop a rival Unix standard to the one under development by AT&T and Sun Microsystems.

Non - Intel type PCs

In a development that could challenge Intel's iron grip on the IBM-oriented personal computer business, several PC makers are reportedly trying to build IBM compatible machines built around the SPARC RISK processor developed by Sun Microsystems.

If they succeed, it could bring on a new generation of PCs that would not only run standard PC software several times faster than the relatively slow Intel processors, but could also run applications software for the increasingly popular Unix operating system.

The development was confirmed by Sun vice president Bernard Lacroute who said he knew of several companies building SPARC – based PCs. "It would be interesting to see a PC two or three times faster for about the same money. I think it would sell."

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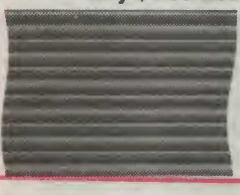

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470uF 180V (PBC)	$4.00
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8700uF 40V	$5.00
9100uF 60V	$6.50
10000uF 40V	$4.50
14000uF 25V	$4.00
14000uF 40V	$6.00
22000uF 10V	$4.00
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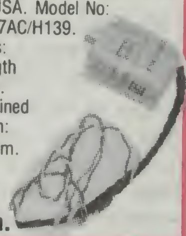

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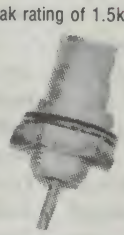

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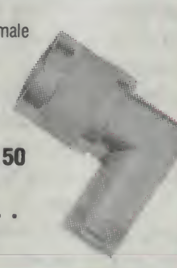

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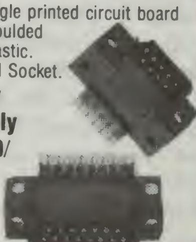

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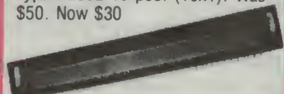

Note: Full data is supplied with each display.

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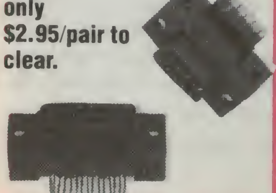

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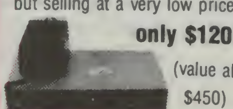

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The Serviceman

Converting an overseas VCR to work in Australia

I have two interesting stories for you this month from one of my colleagues in Victoria. The first concerns his experience in converting a domestic VCR from South Africa to work with Australian TV – the kind of job that frequently involves unforeseen complications.

Like most servicemen, I suspect, I tend to be a bit diffident when a customer walks in with a piece of electronic equipment from overseas, and asks "How much would it cost to have this converted to work here?". This kind of job is extremely difficult to quote for – they can develop hidden pitfalls, and either prove almost impossible or extremely time-consuming and uneconomical.

One way or the other, it's all too easy to end up with egg on your face – either losing money on the deal, or having to explain to the customer that the job really wasn't worth doing after all.

Still, economics aside they *are* usually interesting jobs from a technical point of view. And occasionally they even work out alright, with the customer getting the job done for a reasonable price and the poor old serviceman actually covering his costs.

I was reminded of all this a few days ago, when the following story arrived from my colleague Colin Beeforth, who operates a servicing business in the Victorian town of Dromana. As Colin explains, it concerns a domestic VCR made for the South African market:

The customer walked into the workshop bearing a fairly easily recognised National NV-G7 video recorder. Apart from the odd problem with clogged video heads or the customer not being switched on, a remarkably common condition, these seem to be a fairly reliable VCR. Just as well, because they aren't all that accessible for service purposes.

So far so good. Then the man spoke, and it was quite obvious that I had a problem on my hands. The video had worked quite well before they brought it out from South Africa! Would it be possible to convert it to be used here?

Apparently their Philips TV was being attended to at the Philips Service Centre, and I had been recommended as the nearest National Service Agent.

I promised the customer no promises and fished out the service manual on this model to take home that evening. I usually find it easier to read through complex manuals at home.

Fortunately the South African television system is PAL, 50 fields per second and 625 lines. Not a bad start. At least the tape format and record/play/servo systems would be fine...

The major problems of compatibility lay in the RF sections, the tuner and IF's (sound and vision) and the output modulator. The South African system uses only band III and band IV, so it looked like there wouldn't be any hope of receiving channel 2. Also the modulator output was on UHF.

The output wasn't a major problem, as I have converted a few European VCR's which leave the output permanently on the UHF band, usually somewhere around channel 36. Apart from having no need for the usual TV/VCR switch they seem to operate quite happily with any TV having a UHF tuner.

The first step was to get a test tape playing and see what was happening. As I expected, there was a good test pattern output on about channel 36 but the sound was weak and distorted. Not surprising, as the sound to video separation in South Africa is 6MHz.

RF modulators like the units seen in VCR's usually settle for a fairly simple frequency modulated free running oscillator at the sound IF frequency. This one was no exception and although it took a lot of mechanical disassembly work to get to the slug adjustable coil, this was easily reset to 5.5MHz and gave good sound.

That satisfied the replay situation. Before going any further I decided to check the recording circuits, and fed an audio and video cable into the back panel sockets. Sure enough the unit was recording satisfactorily. Experience can be a hard teacher and I've learnt to establish exactly what does and what doesn't work before launching into a machine with hammer and tongs.

Back to the manual for a closer look at the tuner and IF section. So long as you only wanted channels 6 to 12 and 21 to 68, the tuner looked as though it would suffice. The unit received on its two bands giving a good picture but no sound.

Fortunately the National service manuals are international and carry full information on overseas models. There were quite a lot of changes to be made: two sound IF coils, two SIF trap coils, two ceramic resonators and the video IF selectivity block. There were also quite a lot of incidental resistors and small value capacitors associated with these that would need changing.

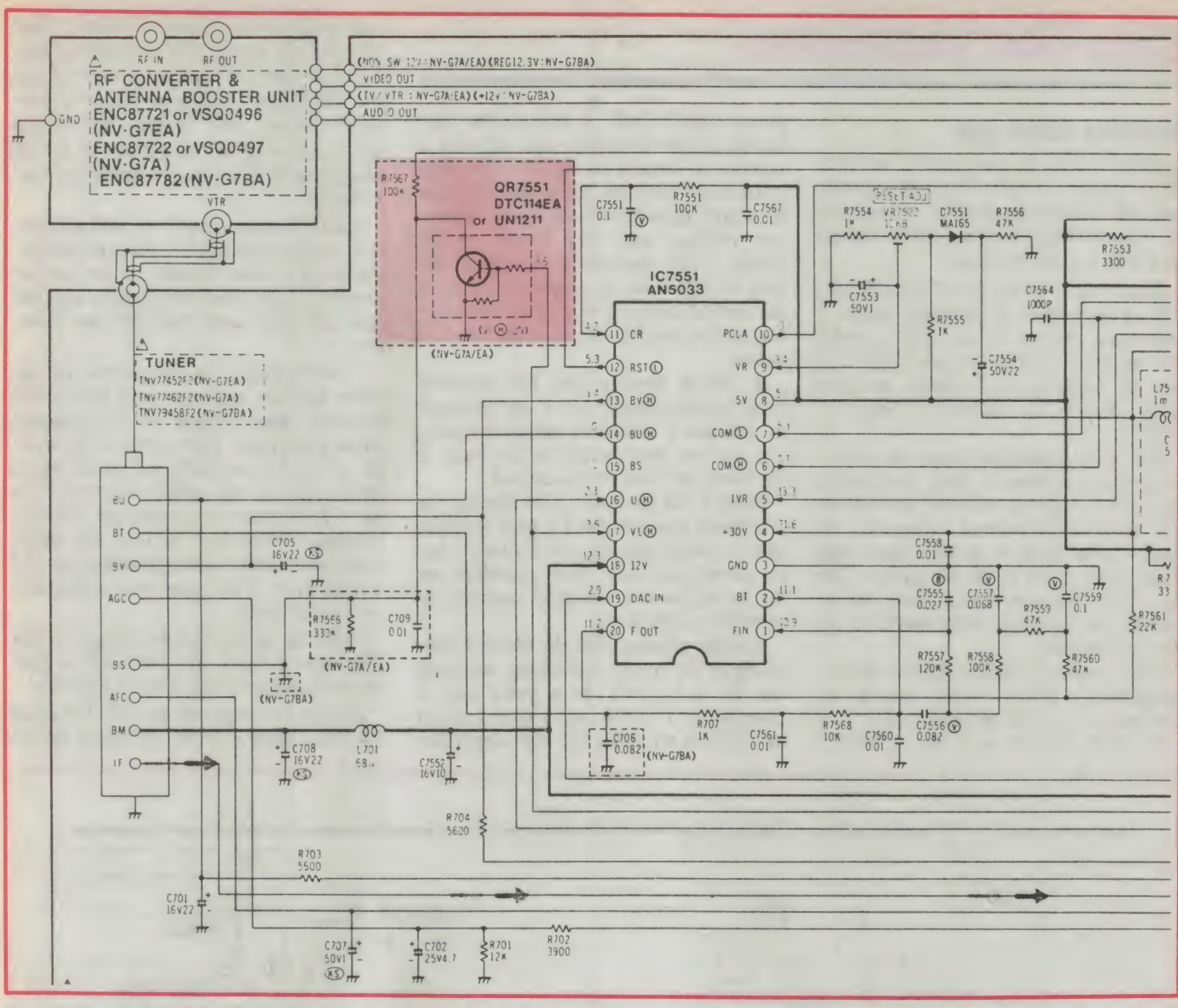
The problem had escalated. I decided to take a quick and dirty approach, to see if there might be any other horrors awaiting.

I adjusted the SIF coils, ignored the SIF traps and the main selectivity block (this would work alright, as it was for a quick test) and replaced the ceramic resonators with 5.5MHz jobs I had in stock. The end result wasn't too bad. It now received and recorded reasonable, if slightly noisy sound.

I assume that the noise was due to the low gain of the video IF section, which was still expecting to see the sound signal at 6MHz above the video carrier.

At this stage I could see that the sound receive problem was surmountable. I decided to have a poke at the tuner and see what turned up. It's hard to explain exactly why, but sometimes you just have a nagging feeling and past experience has shown that those suspicions can often be worth pursuing.

This time I had a nagging feeling that despite the service manual having a completely different part number for the South African tuner, it might still have the required Band I facilities lurking somewhere inside, but not connected. It didn't seem sensible for a company to make a three band tuner and a two band



Part of the circuit for the Panasonic (National) NV-G7 video recorder, discussed in this month's first story. Transistor QR7551 at upper centre was the one missing in the South African version.

tuner when you could reduce the parts inventory and just not connect the third band.

It took quite a lot of work to follow the circuit differences between the two models. There is a single front panel thumbwheel adjuster which sends analog tuning voltage into a large proprietary IC, where it is digitised and stored. The band switch sits under the thumbwheel and its output is connected to another large and largely unknowable IC on the front panel. The signals are converted into a serial data stream, along with the other front panel switches, which via a tortuous path finds its way to the first mentioned IC.

At this point a few checks found that the band switch, although marked with two bands, actually had three positions and they were being faithfully relayed and stored by the tuning control IC. That's where some of the model differences came in. There were a couple of resistors and a switching transistor missing.

Stripping the tuner showed that there appeared to be switching diodes running from a pin that was permanently grounded. Lifting the ground and connecting the Band I bias voltage, I was greeted with fine reception on channel 2!

The missing switching transistor is an unusual device, which has a couple of resistors built into the base lead. These allow it to be driven directly from a logic output without any external components.

Having collected a fair sized parts list, I phoned National Service to order the lot and see what the customer was up for. Apart from the fact that the spare parts chap thought I was mad to take on the job, everything was available except for the video and sound IF parts.

Both IFs and the video demodulator are packed in a plug-in module, which is supplied as a complete unit. The price was quite reasonable and I was delighted at the prospect of not having to do a complete IF alignment.

The parts took a week to arrive and the rest was pretty tame. I checked the tape path, cleaned the heads, costed the job and rang the customer. He was delighted with the end result and went away poorer but happier. So there it is, an unusual job with an unusual ending – the customer was even happy with the bill!

Thanks, Colin, that certainly was an interesting job. Your tip about looking for 'hidden' bands on the tuner is one that I'll bear in mind myself, for the future. It could easily save a lot of unnecessary time and hassles, sourcing a new tuner and then swapping them over.

The Serviceman

Another tuner job

While we're on the subject of electronic tuners, Colin Beeforth actually sent me another small story, concerning an Akai CT-K115 36cm colour television with a tuner problem:

Following on from my VCR story, and still on the subject of electronic tuners, I will relate the tale of an Akai portable TV model CT-K115. By the way these sets are really made in Korea by Samsung, despite the Japanese origin of Akai.

The set in question came in with a temperature dependent fault. Fortunately the fault was pretty reliable: after about five minutes of normal operation, the picture developed a distinct horizontal bend at one point in the test pattern. The rest of the screen remained fine, but the colour and contrast disappeared in the area of the bend.

This peculiar looking effect was accompanied a 50Hz blurting sound, superimposed over the normal audio.

My first reaction was that it was a power supply fault. It had all the hallmarks of power supply ripple affecting a number of circuits in the set. The most convincing evidence being the fact that the screen disturbance was nearly stationary, moving only very slowly up the screen. That movement represents the beat or difference in frequency between the vertical scanning rate of the transmitting station and the cycles of the 240 volt mains.

A lot of modern sets use switched mode power supplies, so I was reluctant to tear into it without a circuit diagram. The set was duly pushed to the back of the bench until the circuit arrived.

When I did get hold of the circuit, the first shock was that the TV used a simple power transformer and thick film IC linear power regulator. Most portables opt for transformerless chopper supplies, to keep the weight down.

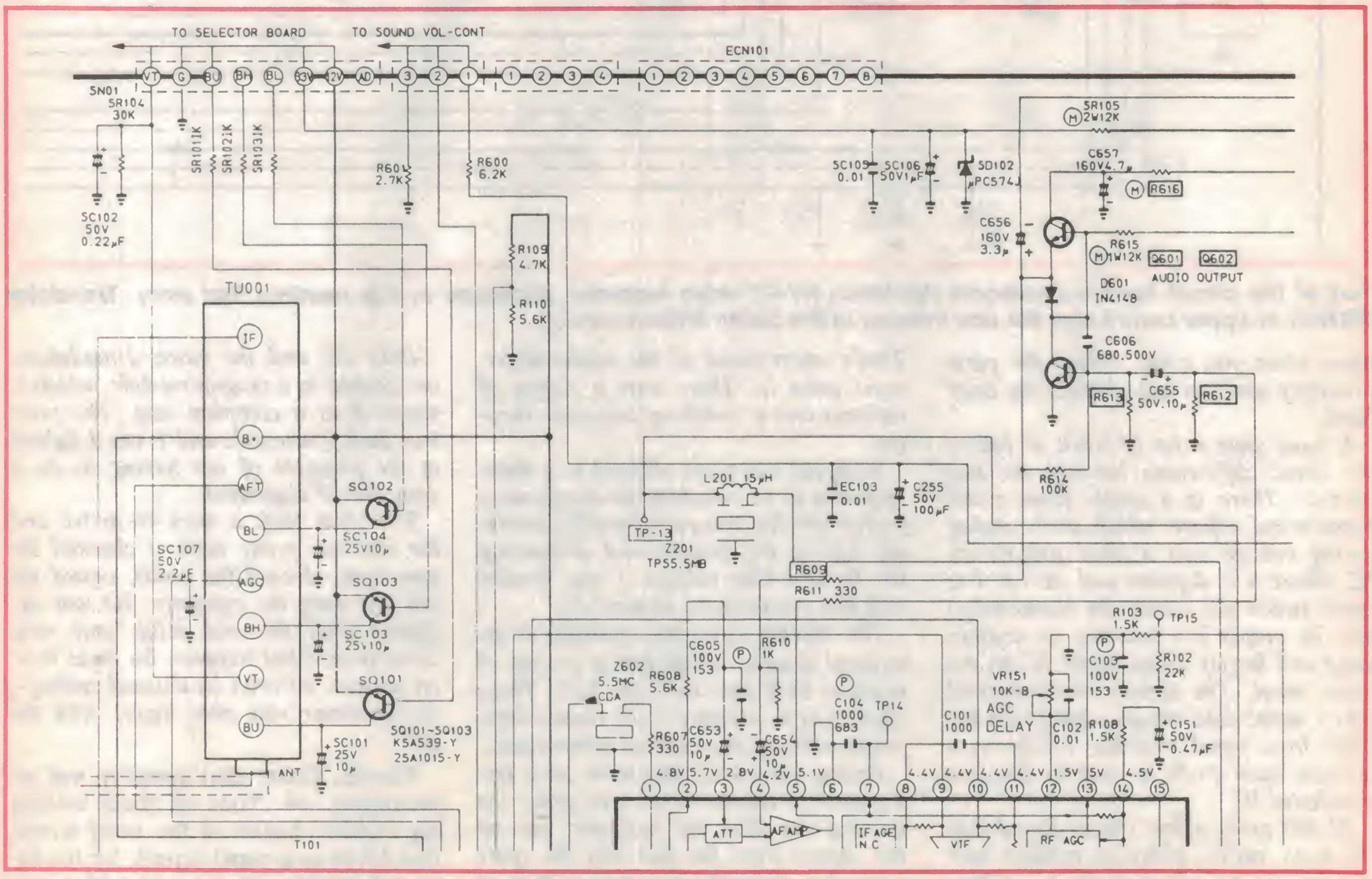
Suitably pleased with the obvious simplicity of the circuit and having no doubt that the job would be a quick one, I charged in. The first step was to connect the CRO to the main 125 volt supply line and wait for the blurts to occur. They did, but the supply line remained a pristine 125 volts DC without a trace of ripple. The plot thickened, and this normally bored and cynical serviceman noted a stirring of interest in the job. It was going to be more of a challenge than I thought.

Apart from a couple of odd transistors, most of the work is done in two extensive ICs. One handles all the colour processing sync and scan signals, and the other the video and sound IFs and detectors.

I went straight to the output of the video detector, and was rewarded with a curiously bent version of a composite video waveform. There right in the middle of the two vertical sync pulses was a nasty lump in the video waveform. On the CRO screen it arched up towards maximum brightness. At least that made sense with what was appearing on the screen, even if the cause was a little less well understood.

Checking all the supply voltages to the chip drew a blank. It looked like a classic hum problem, but without the hum!

Further probing with the CRO showed the same pattern in the RF AGC to the



The circuitry around the tuner, in the Akai CT-K115 36cm colour portable. The 33V regulator IC is shown at upper right (SD102), drawn like a zener diode.

tuner. Sure enough the IF output from the tuner showed the same bump.

To satisfy myself that it was the AGC section of the chip going mad, I cobbled up an alternative DC voltage to replace the tuner AGC signal. The result was most instructive. The fault remained exactly as before.

That didn't leave much to check, except the automatic frequency control voltage to the tuner. It had the offending bump also.

At this point one of those nagging little thoughts in the back of my head became louder and I checked the 33 volt supply to the set of tuning pots. Eureka! The tuning voltage carried the same problem.

A quick squirt of freezer spray on the 33 volt regulator IC removed the problem on the CRO screen and the set performed correctly again.

This IC looks like a typical plastic cased BC series transistor, although with only two legs. In operation it acts like a zener, with a dropper resistor from a higher voltage supply, but they contain active circuits to achieve better stability than a zener. It doesn't take much drift to lose tuning on a UHF station.

Replacement fitted, the set worked nicely and apart from a few moans about the time it took to get the spare part in, the customer was for the most part satisfied with the repair. He should have been, it was a warranty job and he didn't have to pay for it!

The thing that I found intriguing was why had the regulator IC's errant oscillation synchronised with the frame rate of the TV. The supply feeding to the regulator was as clean as you could wish for and the output was well filtered and fed only to the tuning pots. Ah well, I suppose I'll file that along with the meaning of life!

Thanks for the second story, Colin. I can't explain the mains-locked nature of the fault either. Perhaps there may have been just a smidgen of ripple on the supply to the regulator, or some of the stray magnetic flux from the power transformer was passing through the chip itself. Things can be pretty crowded inside one of those portables!

Like you I would certainly have suspected the power supply, from those symptoms. It was a surprise to learn that the same kind of symptoms can come from the tuner bias supply, and without any obvious source of 50Hz. We live and learn, don't we?

That's all for this month, but I hope you'll join me again next month for some more interesting tales from the service bench.

Fault of the Month

Sony KV1300-AS

SYMPTOM: Reduced height. Extreme top of picture folded over, thin white line through centre of pix, and bottom of pix doesn't reach bottom of screen.

CURE: R556 (220 ohms, 1/2 watt) open circuit. This resistor forms part of the divider network that supplies the bias to one of the vertical drive transistors. Without this bias, the other drive transistor will run the vertical scan, at the cost of severe linearity troubles.

This information is supplied by courtesy of the Tasmanian branch of The Electronic Technicians' Institute of Australia. Contributions should be sent to J. Lawler, 16 Adina Street, Geilston Bay, Tas 7015.

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PS: A final clue. The one millionth kit also happened to be the most popular Fun Way into Electronics kit. The $1000 bonus coupon was sealed inside the kit, so you can't cheat! That narrows the field down pretty dramatically, doesn't it.

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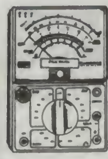

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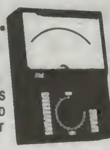

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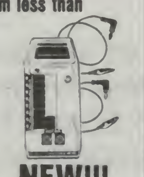

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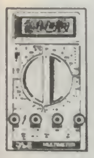

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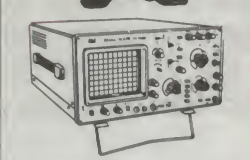

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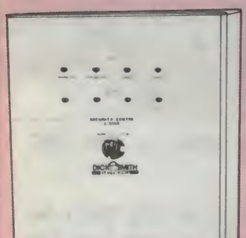

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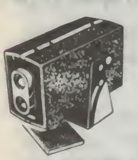

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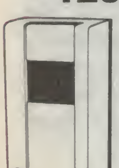

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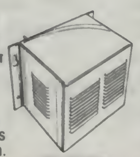

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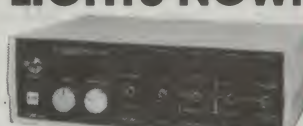

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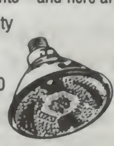

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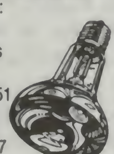

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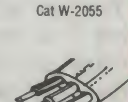

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Merry Christmas and a bright and prosperous New Year . . . from all at Dick Smith Electronics.

DICK SMITH ELECTRONICS

Construction project:

Improved VHF-UHF masthead amp

Here's a design for an improved masthead amplifier, to boost signal strength and improve reception of TV and other signals in the VHF and UHF bands. It will cost you considerably less than commercially available units.

by ANDREW PALMER

For good TV and FM reception, you need to present the RF input of your receiver with signals that are as strong as possible compared with atmospheric noise and the noise that is inevitably generated inside the receiver's own 'front end'. Otherwise, in striving to amplify the weak signals, the receiver will have to amplify the front-end noise to the point where it will become evident on your TV picture as 'snow', or audible as 'hash' in your FM stereo program.

There are various kinds of situation where achieving a satisfactory signal-to-noise ratio can be a problem, but three of the most typical are as follows:

1. You are in the 'fringe area' with respect to the reception of the signals concerned, making it difficult to achieve sufficient signal strength – even with a large and elaborate antenna system.
2. You are in a reasonable signal area, but it is not feasible to use an antenna system capable of producing the strongest possible signals, and your TV or FM receiver is a little elderly. Although too good to throw away, its RF front end has a fairly high noise level – enough to cause an obvious deterioration in reception.
3. You are in a reasonable signal area and your antenna is producing fairly strong signals, but you need to feed a number of sets in various rooms of the house. After passing through the necessary splitter units and cable runs, with their inevitable losses, the signal levels reaching the receiver(s) are not strong enough.

In all of these common situations, re-

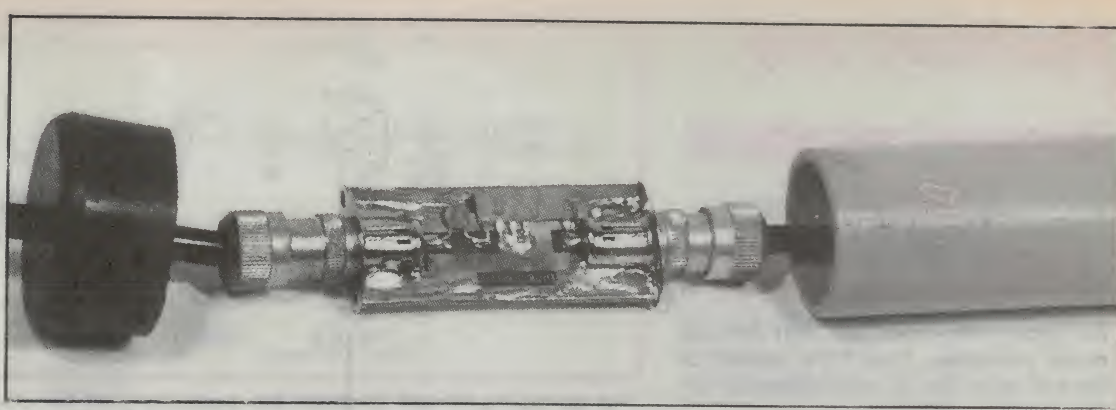
The complete project consists of two parts: the amplifier itself, in the PVC tube in the foreground, and the power feed unit.

ception can generally be improved quite noticeably by fitting a wideband RF preamplifier, preferably at the top of the antenna mast. In other words, a 'masthead amplifier'.

Why should it be at the top of the mast? Basically, because this allows it to amplify the signals picked up by the antenna before they suffer from any attenuation or other deterioration due to the cable and things like splitters.

Fairly obviously, the masthead preamp can't improve the basic ratio between signals and noise as picked up by your antenna. In fact it will inevitably make things slightly worse, by contributing some extra noise of its own. But by placing it as near to the antenna as possible, we maximise the ratio between received signal strength and amplifier noise, and at the same time boost the strength of the signals to be pumped down the cable. Any attenuation introduced by the cable system will therefore affect both the amplified signal and amplifier noise equally, without affecting the ratio between them.

With the alternative approach of fitting an amplifier down at the receiver end of the cable, the signals will already have suffered some attenuation by the time they reach it. This will immediately provide a poorer ratio between the signal at the input to the amplifier, and its own inherent noise – preventing it from giving as much improvement.



A look inside the PVC tube, showing the small amplifier PCB and the way that the cables connect to it via co-ax plugs and sockets.

By the way, although a masthead amplifier inevitably contributes some noise of its own, this is quite small and typically rather less than that added by the tuner section of a TV receiver – particularly if the receiver is not one of the latest models. And of course fitting it to the top of the mast allows it to operate on the signals at the most favourable point.

So if you're in a fringe area, or have a less-than-ideal antenna system with a slightly older receiver, or need to feed the signals through quite a few splitters and cables, a masthead amplifier could well give you noticeably better reception.

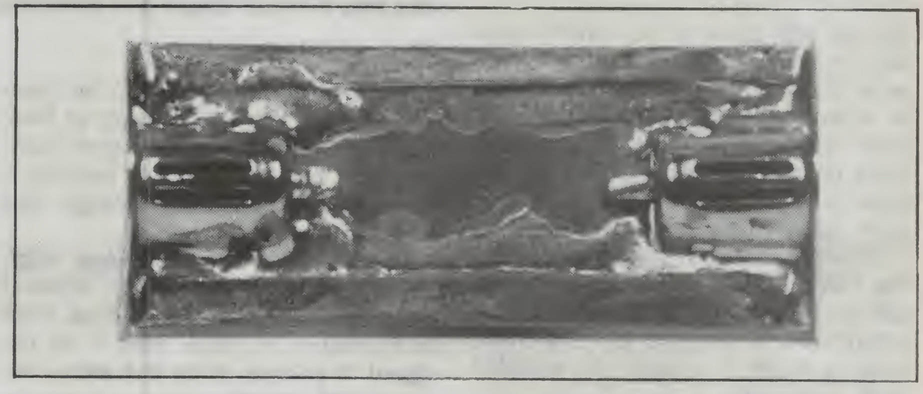
How about the flip side – does a masthead amp have any drawbacks? Certainly. Because they are a wideband amplifier, handling all the channels together, a really strong signal on one channel can cause amplifier overload and produce interference with the other channels.

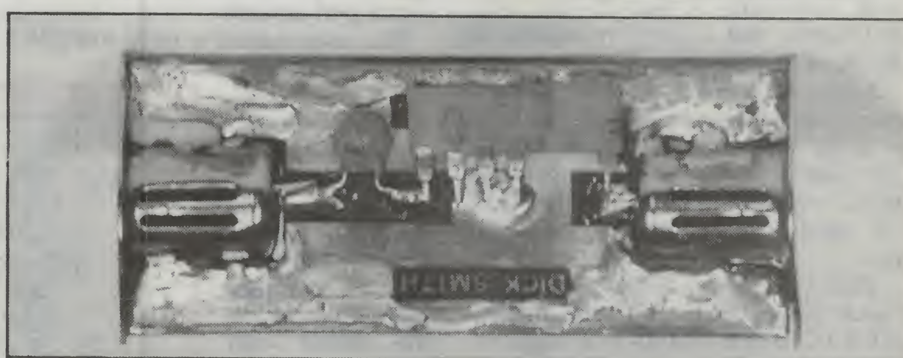
It's *not* likely to be of much benefit if you're in a strong signal area, or where you have one really strong local signal and you're trying to improve the reception of much weaker signals. Unless you take special steps to prevent the strong signal from overloading the amplifier, it could well make things worse rather than better.

The same tends to apply where you have a strong local VHF signal from a primary transmitter, and some weaker UHF signals from translators.

Of course a masthead amplifier can't in itself do much with other kinds of reception problems either – like 'ghosting', which is caused by multiple versions of the same signal coming by different paths. With this kind of problem, all the amplifier might let you do is swing the antenna around to a position which minimises the ghosting, making up for the reduction in wanted signal strength with its additional gain.

A masthead amplifier isn't a universal cure-all, then, although it can improve reception in a lot of situations.





Two close-up views of the amplifier PCB, showing the component side (above) and the ground-plane side (top). Only four actual components are needed: the hybrid IC, a capacitor and two co-ax sockets.

About masthead amps

There have been quite a few designs published for VHF-UHF masthead amplifiers, in various magazines. The last one published in *Electronics Australia* was in the August 1979 issue, although a similar Booster/Distribution amplifier designed to be mounted inside the roof (rather than at the masthead) was described in the March 1987 issue.

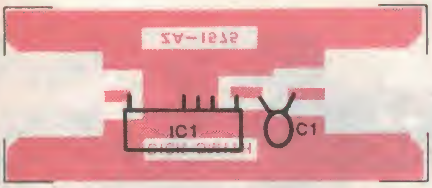
Most of the designs published in Australia in the last 10 or so years have been based on one or another of a family of hybrid VHF/UHF wideband amplifier IC modules manufactured by Philips Components – the OM300 series. These devices are expressly designed for this kind of use, offering good amplification and low noise performance up to about 860MHz.

The current design is no exception, using the device that has probably been most often used: the OM350. This provides typically 18dB of gain over the band from 40MHz to 860MHz, with a noise figure of 6dB.

Incidentally, *noise figure* is a measure of the noise introduced by the amplifier itself. It is actually the ratio of *input* signal-to-noise ratio to *output* signal-to-noise ratio, so that the lower the noise figure the better. An ideal amplifier would inject no additional noise of its own, so that the ratio between input and output signal-to-noise ratio would be unity or 0dB.

The UHF tuners in many older TV receivers typically have a noise figure of somewhere between 11 and 14dB, so

Masthead amp



For those who need just that little bit more guidance, here's the details of how to wire the IC and capacitor on the amplifier PCB.

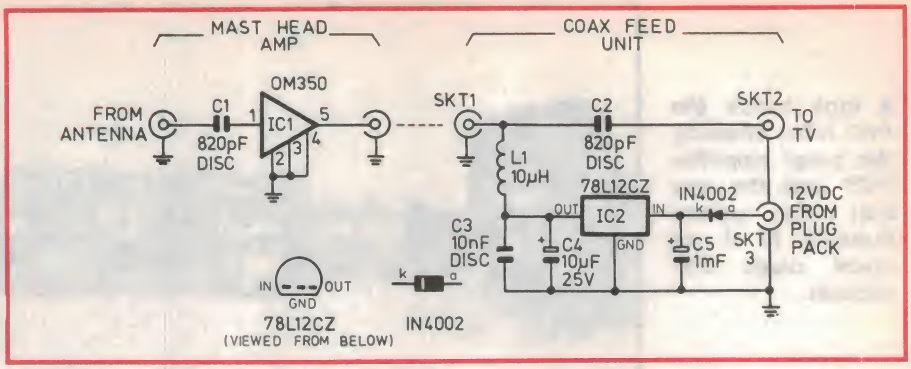
that the 6dB figure of the OM350 is obviously rather better. Since the overall noise performance of a receiving system is determined almost entirely by the noise figure of its input circuitry, this gives the OM350 the potential to give quite a significant improvement when used 'up front' in a masthead amplifier.

Electrical and mechanical details for the OM350 are shown in Fig.1. As you can see, it is basically a two-transistor amplifier with untuned and low value loads in order to achieve the required wide bandwidth. It has 75-ohm input and output, and is therefore capable of driving a co-axial cable.

Made on a small ceramic substrate measuring 19 x 9mm, it is encapsulated in resin. Five pins are brought out on one side, for the input, output and three common connections. The 12V DC supply is fed in via the signal output pin.

Philips recommends that the OM350 should be mounted on a small double-sided PC board, and gives a suggested layout. Most of the earlier designs published have used this layout or something very close to it, and have generally given reasonable results – at least for some constructors. However others have found the results disappointing, and there have been suggestions that minor layout and construction variations could have caused troublesome peaks and notches in the response.

Although on the surface there's not much involved in using the OM350 in this kind of application, it's actually a good deal more critical than you'd think. At UHF, an extra millimetre of lead length or PCB pattern can resonate with stray capacitance, to produce quite significant changes in gain at certain frequencies. Similarly even short lengths of signal path which do not maintain the correct characteristic impedance level can produce mismatch reflections, setting up standing waves and again producing undesirable peaks and notches.



The complete circuit for both the amplifier and the power feed unit. As you can see, it's very simple and straightforward.

This design

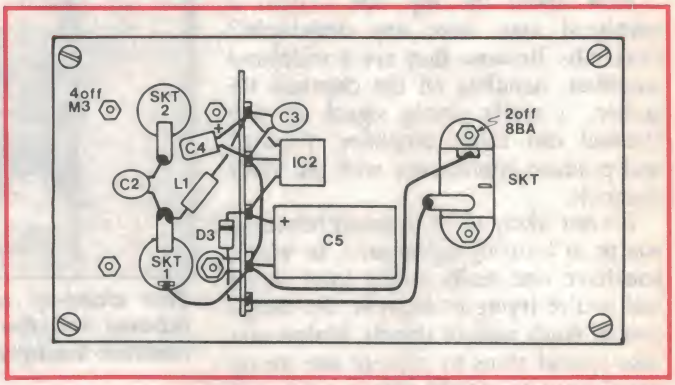
The design described here has been developed by the R&D people at Dick Smith Electronics, who have spent quite a deal of time and effort to investigate the problems with earlier designs, and find ways around them.

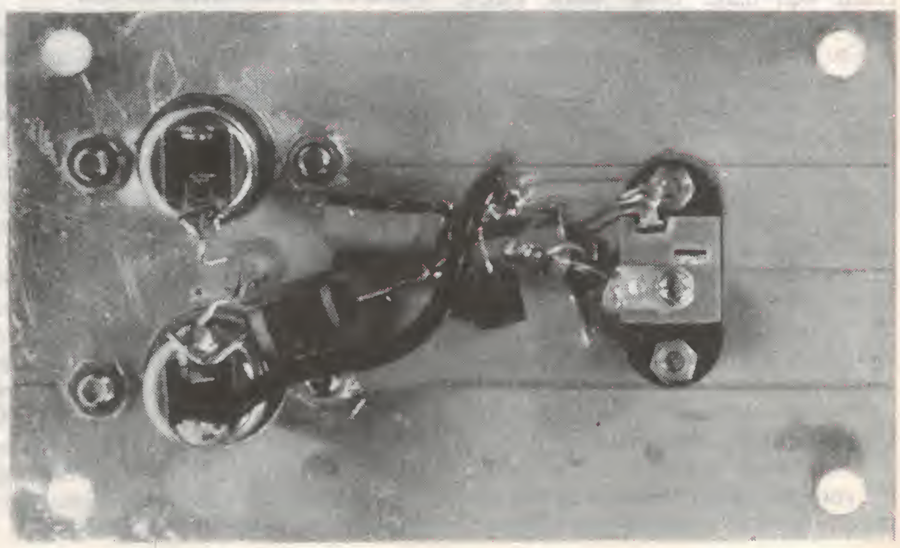
They've ended up with a design which may not look all that much different from the others, but differs from them in a number of subtle ways – all designed to achieve better and more consistent performance.

The actual circuit is quite straightforward. The OM350 itself forms the heart of the masthead amplifier proper, with an input coupling capacitor C1 to prevent its bias from being disturbed by the antenna or its balun. Power to the OM350 is sent up the co-ax cable from a small matching feed unit, via shunt inductor L1. Output coupling capacitor C2 again prevents the DC supply from being disturbed by the input circuitry of the receiver.

The DC power is derived from a standard 12V DC plug pack supply, with a small three-terminal regulator

The diagram at right and picture below illustrate two different ways to wire up the power feed unit. The approach at right gives a neater result, however.





chip IC2 used to provide smoothing and regulation. Diode D1 is used to prevent damage to the regulator if the plug-pack polarity is accidentally reversed.

So there's nothing terribly different about the new design in terms of its circuit. It's in the area of physical layout that it differs, particularly for the masthead unit itself. Great care has been taken to minimise excess lead lengths, and reduce any discontinuities in terms of characteristic impedance.

As with the original Philips recommendations, a double-sided PCB is used. However in this case the OM350 and its input capacitor are not mounted on the opposite side of the board from the copper tracks. Here they are mounted directly on the track side, to allow even shorter lead lengths.

This approach has a number of other advantages as well. One is that there is less disturbance to the 'ground plane' action of the copper on the other side of the board. Another is that the signal tracks can be more easily designed to function as striplines of the correct impedance, to provide fewer discontinuities in the signal path.

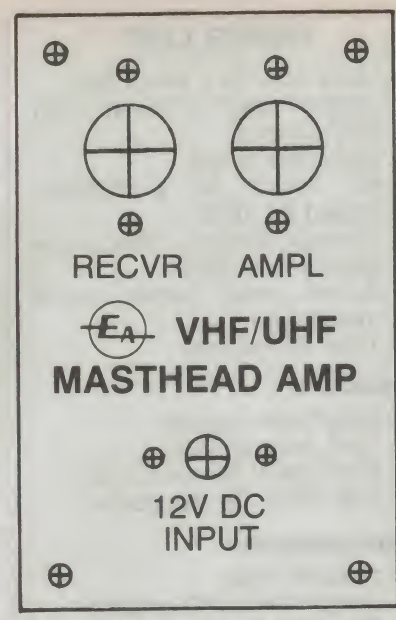
To improve the performance still further, the DSE people have designed the PCB so that the co-ax connectors mount directly to it in axial fashion, again with minimum disturbance to the characteristic impedance in the signal path. The outer earthed sleeves of the sockets can also be bonded directly to the 'ground plane' copper on each side of the board, for minimum inductance.

And finally, to make sure that the 'ground' copper on both sides of the PCB does indeed provide a true unipotential ground, the two are bonded firmly along both sides by lengths of copper shim soldered full length.

All of these steps have produced a design that is straightforward and quite easy to reproduce, yet provides a consistent high order of performance. The measured response of all units produced to date is within 1dB from 10MHz to typically 1GHz. There is only one small dip, of less than 1dB, at around 630MHz – which does not appear to be amenable to easy removal. This has no noticeable effect, however.

This performance appears to be significantly better than has been achieved by most previous designs. In fact it is achieving very close to the maximum performance possible from the OM350 – but of course this will depend on you wiring it up in the correct fashion. More about this shortly.

By the way, the PCB design for this project is the property of Dick Smith Electronics, and cannot be reproduced commercially by other firms.



Above: Here is the front-panel art for the power feed unit, actual size. A photocopy makes a handy template when drilling the front panel. At right is a view of the final panel after assembly.

The board is designed to be housed in a short length of PVC electrical conduit, with matching tightly fitted end caps to keep it waterproof. The idea is that the input and output co-ax cables pass through the end caps, and then terminate in plugs which mate with the sockets on the PCB. The complete assembly can then be put together inside the PVC tube, with 'Silastic' or similar sealant around the cable entry holes and the end cap edges. A strap clip can then be used to mount the amplifier on the mast, near the antenna terminals.

The power feed unit is housed in a small 'UB5' size utility box, measuring 83 x 54 x 28mm. As there are very few components involved in this unit, they are simply wired point-to-point.

Construction

The most critical part of the project is the actual masthead amplifier assembly, of course. But this needn't present any problems, provided that you tackle it in a logical fashion.

First cut the copper shim into two strips 55mm long by 15mm wide. Crease these down the centre, and bend them around the edges of the PCB so that they lie flat on the copper of both sides. Then solder both of them carefully along the full length of both sides, so that they each bond the two copper laminates together.

Next take the two Belling-Lee panel-mount sockets, and solder them carefully into the appropriate cutouts at the ends of the PCB. Take care to position them with the centre spigot just resting on the central stripline track, so that it won't be moved out of position during the soldering. Note that the outer sleeves of the sockets should be soldered to the adjacent 'ground-plane' copper along both sides of the sockets themselves, and on both sides of the PCB as well.

With all of this 'heavy' soldering done, you can now solder in the OM350 and its input coupling capacitor C1. For both of these, the idea is to trim their leads as short as possible, while still providing *just enough* exposed metal for soldering to the PCB tracks (say 1.5 to 2mm at most). Then you do the actual soldering as quickly as possible, so that the components are not damaged by overheating.

Note that the five pins of the OM350 are not arranged symmetrically. The input pin and the three earthing pins are close together near one end, while the output pin is further away at the other end. Make sure you wire it the correct way around, with pin 1 nearest capacitor C1.

Assembly of the power feed unit involves little more than drilling and reaming out the holes for the three sockets, using a photocopy or tracing of the front panel artwork as a template.

Masthead amp

Then you can carefully stick on the Dynamark dress panel, mount the sockets and wire things up.

Wiring of the small components is a little tricky here because of the point-to-point wiring, but shouldn't present any problems if you use the wiring diagram and internal photograph as a guide. Two lugs cut from a small 7-lead tag-strip are used to support the components as shown.

The main point to watch from a performance point of view is that the leads of coupling capacitor C2 are again kept as short as possible, to minimise series inductance. To make this possible, the centre spigots of the sockets should be bent over towards each other. Then the capacitor leads should be cut to the shortest possible length which still allow C2 to span between the two. The other things to watch are that regulator IC2 is connected into circuit correctly, and that diode D1 and electrolytic capacitors C4 and C5 are also connected in the right way round.

PARTS LIST

1 Utility box, 83 x 54 x 28mm
1 120mm length of 32mm (OD) PVC conduit
2 End caps to suit
1 PC board, 55 x 22.5mm, coded ZA-1575
4 Co-axial sockets, Belling-Lee panel mount type
1 2.5mm power socket, panel mount type
1 10uH RF inductor

Capacitors

2 820pF disc ceramic
1 10nF disc ceramic
1 10uF 25VW RB electrolytic
1 1mF 25VW RB electrolytic

Semiconductors

1 1N4002 diode
1 OM350 VHF/UHF amplifier
1 78L12CZ regulator

Miscellaneous

Length of copper shim, 110mm x 20mm; small 7-way tagstrip; dress panel for utility box; machine screws and nuts, etc.

Testing & installation

When both units are finished in the electrical sense, it would be a good idea to connect them temporarily together via a short length of co-ax, and try them out to make sure everything is working correctly. It is better to do this *before* you fit the amplifier unit into its protective tube, and mount it up on the mast!

The easiest plan is to connect the amplifier and power feed unit into the antenna lead right at the receiver, and then use the receiver to check that they're working. With power supplied to the feed unit from a 12V DC plug pack, the signals fed to the receiver should be noticeably stronger via the amplifier setup than with direct input from the antenna.

If all seems well, you're now ready to fit the amplifier unit into its housing and instal it up on the masthead.

The procedure here is to first drill a hole in the centre of each of the PVC end caps, just large enough to take the co-ax cable snugly. Then you'll need to cut the antenna downlead, say 30cm or so from the antenna end, and poke each of the two cable ends through a cap (from outside to inside).

This done, you then fit a Belling-Lee type co-ax plug to each one, soldering the connections carefully. The PVC tube is then slipped over the amplifier board, and the plugs fitted into the appropriate socket at each end of the board to complete the connections. After this the end caps can be slid along the cables and over the ends of the PVC tube, to complete the housing and hold everything together. The length of the tube is carefully set so that when the caps are fully on, they will hold the co-ax plugs firmly in the amplifier sockets.

The final step is to add fillets of 'Silastic' or similar sealant around the cable entry points and the edges of the caps, to seal the complete unit and keep out moisture. It would be a good idea to add a dollop of the same sealant to the antenna end of the short input cable, to prevent moisture from seeping down inside the co-ax.

Needless to say the amplifier unit is mounted up on the mast near the antenna terminals, using a strap clip around the outside. The power feed unit is located at the receiver end of the cable for a single-cable system, or just before the splitter unit if you are using one. If you're using more than one splitter, the feed unit will need to be fitted just before the *first* splitter encountered by the signals as they pass down the cable.

That's about it. There's nothing to adjust – just hook it all up, apply the 12V power to the feed unit and away it goes.

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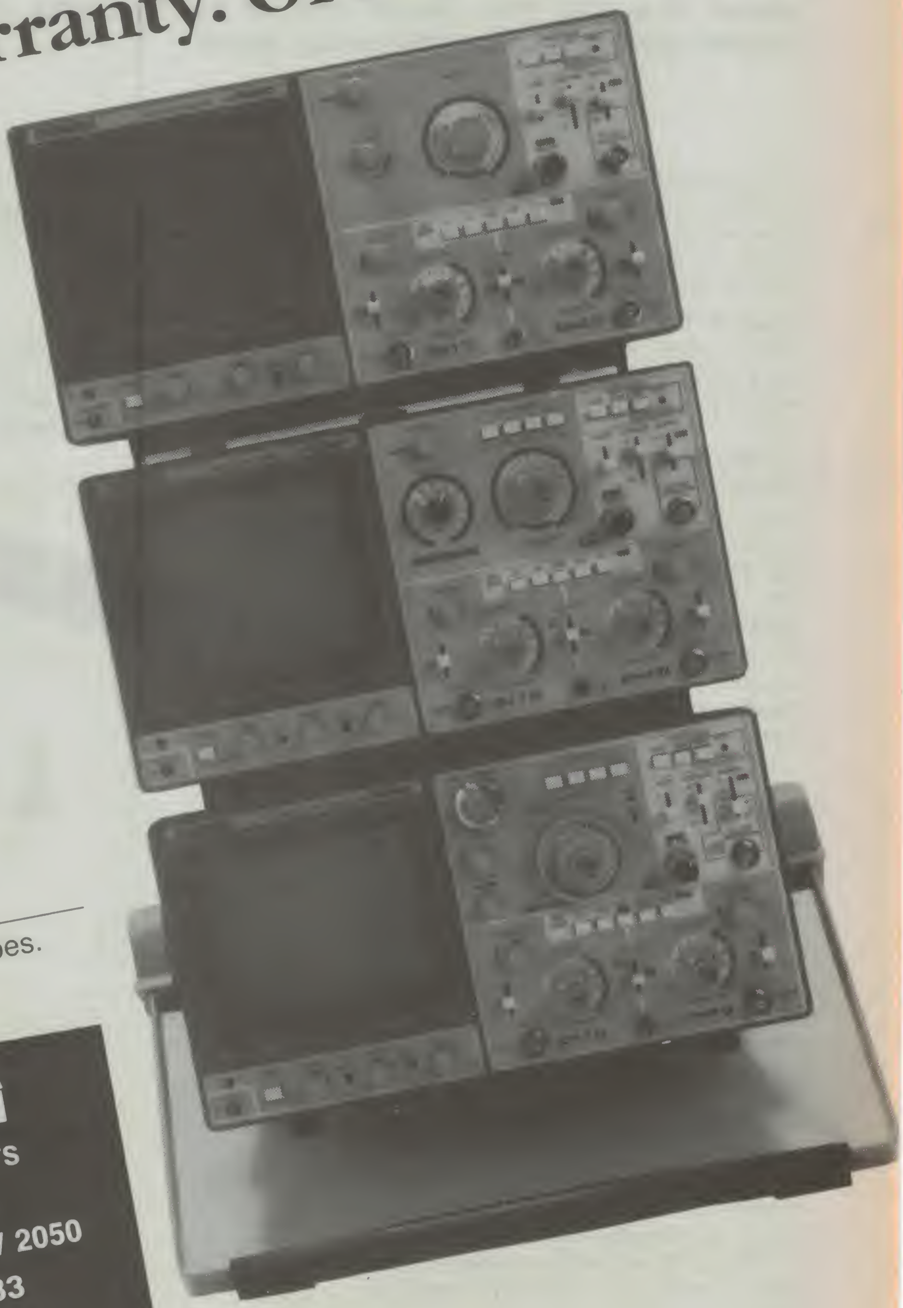

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Construction project:

Super Timer

Here's a low cost but very flexible 4-digit timer which can be used to measure intervals from a few microseconds to hundreds of seconds. Very handy for checking times and speeds involved in all sorts of physical events – like the speed of a slug from an air rifle, or the time your camera shutter stays open for each shutter speed.

by IAN PAGE

Ever wanted to measure the speed of a bullet, a golf ball, or a snail? The timer to be described will measure intervals of time ranging from microseconds to 999.9 seconds, with an accuracy equal to that of the timebase plus or minus 1 digit. A four figure display provides good resolution with high accuracy when ultra short times are being measured.

Three types of inputs are provided: a START/STOP input T1 which can be used to measure, for example, the ON period of a 555 timer; or T2 and T3 which provide separate inputs for start and stop signals. Input C accepts a clocking impulse (suitably conditioned) to operate the display as a 1-9999 counter. A six position switch permits a suitable timing range to be selected at will.

While the high resolution possible may not be required for most applications, it does provide the born experimenter with the means to make all kinds of timing measurements with which to amaze his friends, or satisfy his own curiosity. The scope of these depends upon the ingenuity displayed in the design and construction of various triggering devices required to start and stop the timer.

For instance, the author, having purchased a high powered air rifle, wished to check the maker's claim of 280m/s muzzle velocity. Having decided upon a method of triggering the timer, the construction of the timer itself became a matter of providing the required accuracy. Need for an accurate timer for the work bench gave additional justification.

For those interested in the bullet speed measurement a description of the trigger device used is given at the conclusion of this article.

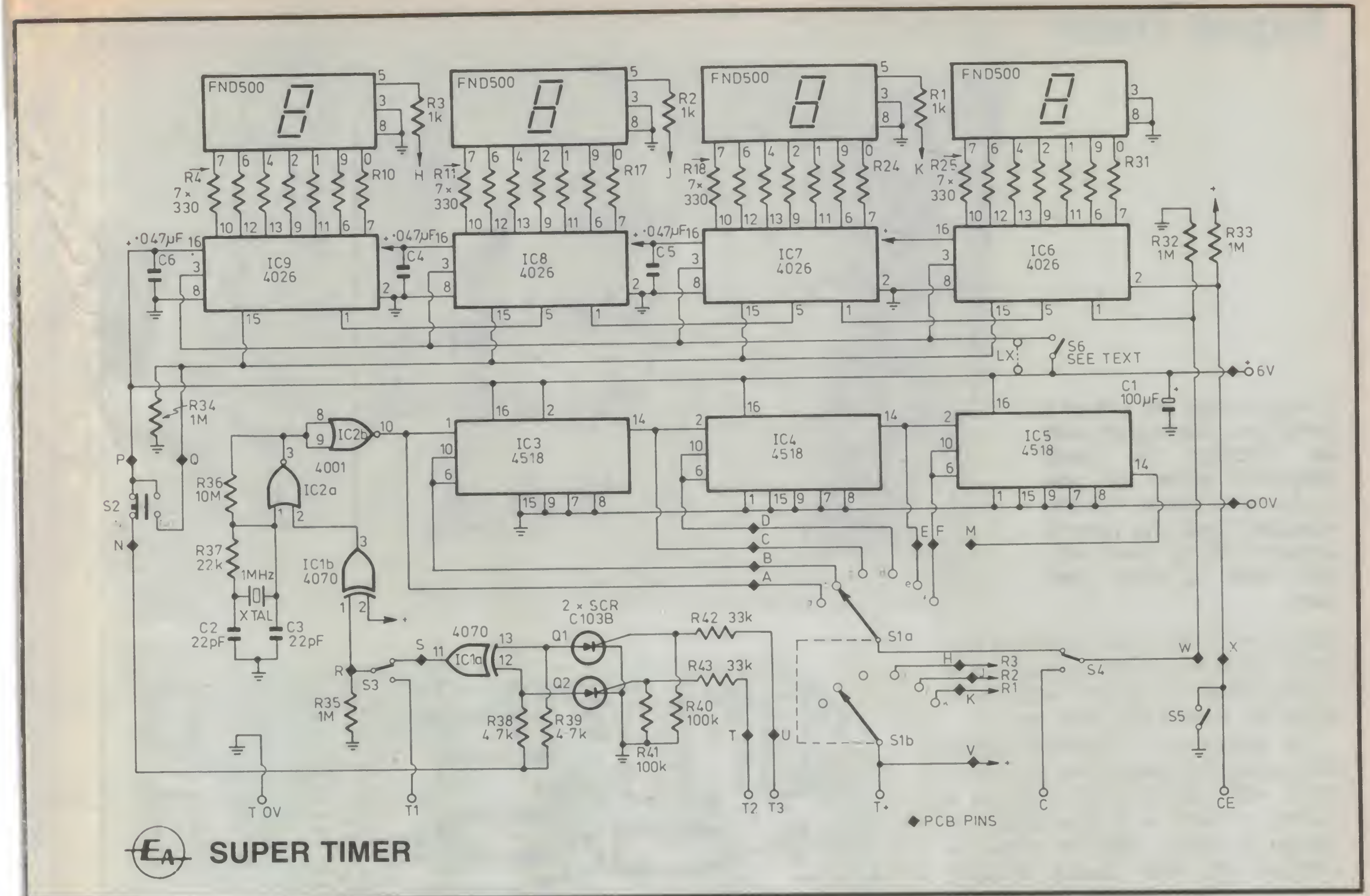
How it works

Basic accuracy results from the use of a crystal oscillator. This comprises a 4001 NAND gate with resistors, capacitors and 1MHz crystal forming a tuned network. The dividing string consists of three 4518 dual decade dividers (ICs 3,4 and 5). At each decade, commencing with the oscillator, an output is taken via a six-way selector switch S1a and switch S4 to the clock input of a counter, using four 4026 counter/display drivers (ICs 6-9).

Control of the timing period is obtained by disabling the oscillator via pin 2 of IC2a. If this pin is held low the oscillator runs. When taken high, it stops. Control at this point ensures that maximum accuracy of count is achieved.

There are two timing inputs: T1 is used to measure the duration of an output, such as a 555 monostable. When T1 is switched in via S3, it is held low by R35. A HIGH received at T1 will cause the output of EX-OR gate IC1b at pin 3 to go LOW, thus enabling the

A view of the completed timer, which the author housed in a home-made case.



The complete circuit of the timer, which can be used to time a wide variety of events.

oscillator. When T1 goes low the oscillator stops. 1MHz clock pulses are divided (counted) by the decade dividers, whose output is drawn off at the desired frequency by S1a, from which the pulses are taken via S4 to pin 1 of the counter display IC6 and thence down the counter chain to IC9.

Inputs T2 and T3 are used when separate start and stop signals are required to time extremely short intervals, or when the two trigger points are individually controlled, such as, for example, when timing a slot car, or the speed of an arrow. These terminals require HIGH signals, to fire the thyristors Q1 and Q2 which first must be switched off by using push switch S2 to momentarily disconnect supply to them.

If a HIGH signal is received at T2 or T3 (it doesn't matter which) the corresponding thyristor will fire, taking its load resistor R38 or R39 to ground. With one input HIGH and the other now LOW, the output of EX-OR gate IC1a at pin 11 will go HIGH, taking pin 1 of IC1b HIGH. Since pin 2 of this gate is tied to the positive rail, output at pin 3 will go LOW, thus enabling the oscillator.

When a HIGH signal is received at the other input terminal T2/T3, the second thyristor will fire, taking its load resistor to ground and causing the other input pin of IC1a to go LOW. This will result in pin 3 of IC1b going LOW, thus disabling the oscillator.

The use of thyristors to start and end the timing period rules out any possibility of false or ragged triggering inputs resulting in faulty readings.

Terminal C allows an external count signal to be applied via S4 directly to the clock pin 1 of IC6, thence to the remaining counters. For counting to commence, pin 2 of IC6 must be held low. Normally it is kept high by R33, but switch S5 when closed grounds it and allows counting to begin. S5 must be kept closed for all timing operations. For counting, it may be used as an ON/OFF switch, or alternatively, it may be left open and the count enabled by an external switch connected at terminal CE.

TABLE 1
MEASUREMENT RANGES

Switch Position	Time Range
A	0 – 9.999 ms
B	0 – 99.99 ms
C	0 – 999.9 ms
D	0 – 9.999 seconds
E	0 – 99.99 seconds
F	0 – 999.9 seconds

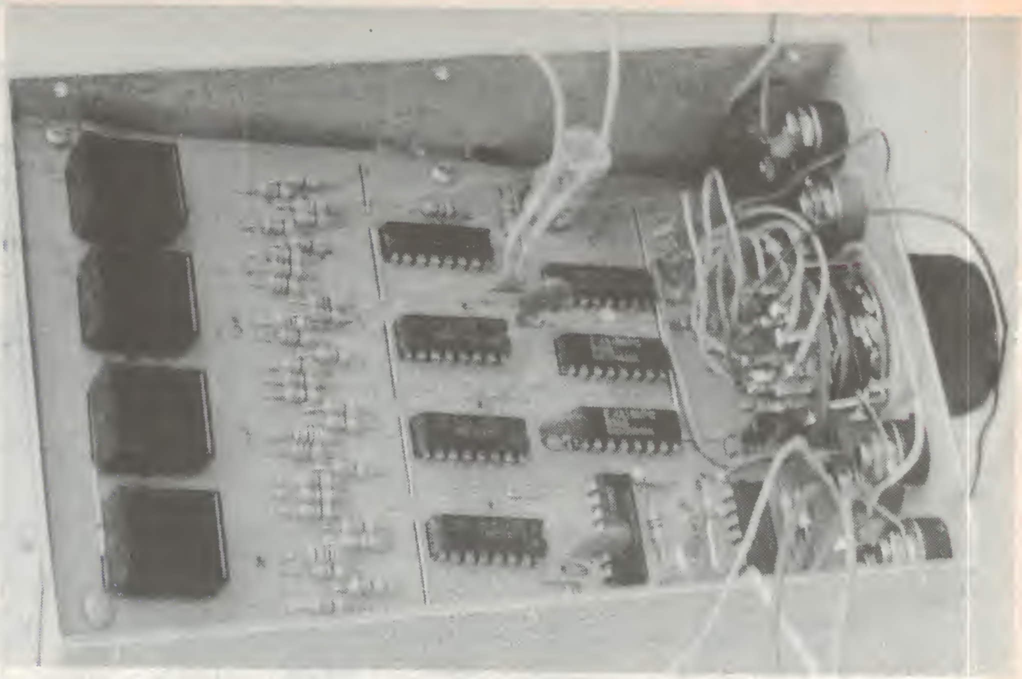
Table 1: The 6 measurement ranges.

Timing ranges

It should be noted that the contacts of switch S1a are identified by letters which represent timing periods as shown in Table 1.

A connection to pin 14 of IC5 is provided (referenced by letter "M"), at which point a 1Hz pulse is available which can be used as a one second standard clock signal – or, if desired, switched through the six position switch in lieu of one of the other frequencies.

The second pole of the 6 way switch (S1b) is used to switch in the usable decimal points on the display, giving readings of xxx.x, xx.xx, and x.xxx seconds. The provision of decimal place indications for the higher frequencies was



A view inside the author's prototype, showing the way he mounted the board diagonally inside the case to conserve space. The text describes how the case is constructed, for those who also wish to make their own.

thought to be not worth the effort, as a visual inspection of the display while running leaves one in little doubt as to where the decimal point must be.

The display can be blanked without interrupting the count, using S6. This is useful when operating the timer on a battery, as there is a considerable reduction in current when the display is switched off. With display blanked, 4.5mA is drawn at 6 volts. With the display ON, consumption is about 120mA.

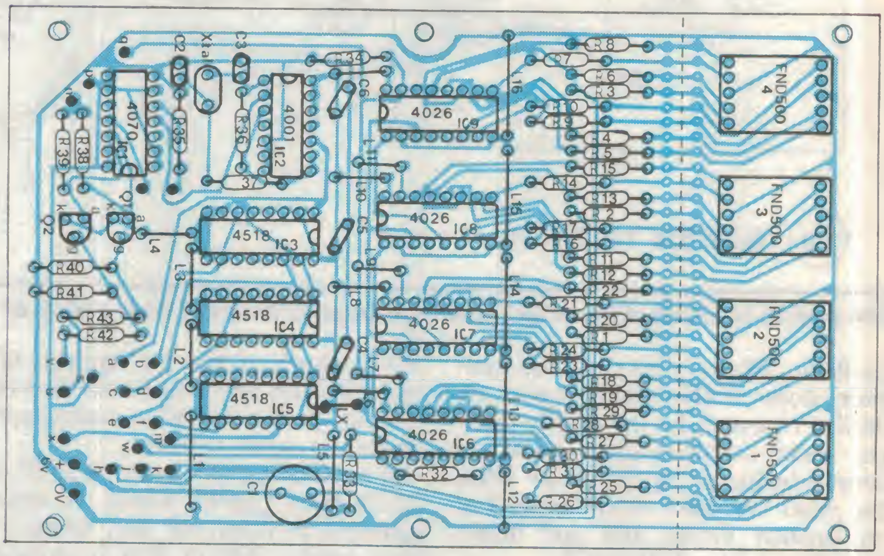
Where power consumption is not a problem, the blanking switch S6 can be omitted. In this case the link LX must be fitted. If the switch is used the link is left out.

The display need only be read at the conclusion of the timing period. Switch S2 is a momentary action 2-pole changeover which serves two purposes. When pressed it (a) resets the display to zero, and (b) resets thyristors Q1 and Q2 to the OFF state.

Resetting of the display is done by making the reset pin 15 of each counter/display driver HIGH momentarily by closing the NO contacts of S2. Also, when S2 is operated, the NC contacts disconnect power to Q1 and Q2, causing them to reset to their OFF state.

Oscillator

The quartz crystal should not be very far off the nominal frequency, but if it is, a moderate adjustment can be made by altering the value of C2 or C3. Use of a frequency counter is helpful but can introduce its own (unknown) error. In the following section reference is made to this and a method of determining the accuracy is given.



The PCB overlay diagram, showing the location of all components. Take care with the polarisation of all ICs, also the LEDs.

Construction

Some thought must be given as to how the board and controls are to be housed. This will depend upon whether the unit is to be used indoors, outdoors, or both, and for what purpose.

If to be used outdoors, a battery supply must be considered. In this case, it is advisable to fit the display switch S6 so as to conserve battery power. If power consumption is not an issue, omit S6 and fit a link in the PC board at this point.

If the timer is to be used only for fairly short intervals, four AA cells should suffice. In this case, they could be mounted in the project box.

Next you'll need to tackle the problem of keeping it all compact while at the same time providing room for switches and plugs, and their connections. And last but not least, how is the display to be made visible. Separating the display section from the main section involves extra work in reconnection and should be avoided if possible.

In the author's version, the problems were solved by mounting the PC board at an angle to the horizontal so as to provide room under the display end of the board for a 4 x AA battery holder. At the other end, the tilted PCB also provided room to mount the rotary switch and six input sockets above the board – see Fig.1. An extra socket was provided to give a connection to the 1

A trigger for camera shutter timing

Used in conjunction with the Super Timer, this device will check the speed of shutter settings on cameras with focal plane or between the lens shutters, provided that the film window at the back of the camera is accessible. Modifications to the size of cover plate (see drawing) may be necessary to adapt to smaller or larger film windows.

The cover plate (60 x 38mm or as necessary) should be made of an opaque material – PCB with the foil intact is ideal. Make the tube by rolling a strip of 30mm wide paper on a 7/32 or 5.5mm drill shank, pasting adjoining layers together until a thickness of about 3mm is built up.

The tube material MUST be opaque and it may be necessary to add a final layer of aluminium foil or black paper. A metal tube of the right bore is ideal. Use a fine paint brush to paint the inside of the tube a matt black. Indian ink or poster paint is suitable for this.

Now cut a piece of strip board 50mm long and five tracks wide, and remove all five tracks for a distance equal to the diameter of the tube. Work out a suitable layout for the circuit wiring shown and mount the resistors and BC557. Now turn the circuit board upside down and hold it firmly in a vice with the board horizontal. Place the photo diode with its leads pointing downwards thorugh holes in the blank end of the board, splay the diode leads out a little to keep it in place, and use Araldite to cement the tube to the strip board as shown.

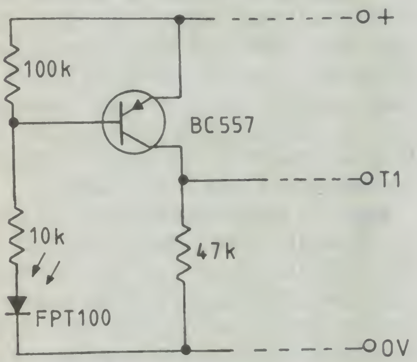
When the cement is set, remove from the vice, and cement vertically to the cover plate as shown. See that the tube does not project through the plate by more than 1mm, or damage to the shutter could result.

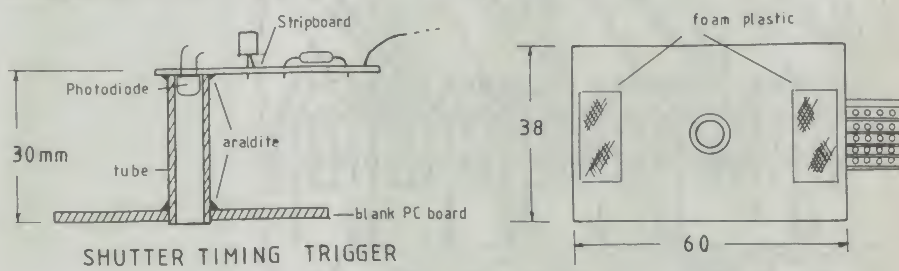
Check the polarity of the FPT100 photo diode and connect to the strip board with short leads. It is important that the diode cannot pick up light entering the back of the tube, and it may be necessary to block any small opening with black paper, pierced for the diode leads. Now connect three flexible leads to the strip board, and solder banana plugs to their ends to allow connection to the timer as shown.

Plug in the timer and check that, with the leads connected correctly, the timer switched ON, and the device held flat against a table, for example, the timer does not begin to count. Raising the plate to allow light to enter should start the timer. It should be appreciated that light is striking the diode from a comparatively small opening, and therefore the tube will need to point at a fairly bright light source.

With the camera set on full aperture, and the back open, hold the device over the film window, set the timer to zero, and with the camera pointing at an open window or bright light, trip the shutter.

To judge how the shutter markings compare with measured time, it is advisable to first convert the fractional shutter speeds to decimal, for example, 1/60=0.0166, 1/125=0.008 and so on. While marked shutter speeds are not exact, there can be wide differences between nominal and measured speeds, due perhaps to the age of the camera. This can be important particularly in the case of 1/60 sec, which speed is almost invariably used for flash photography.





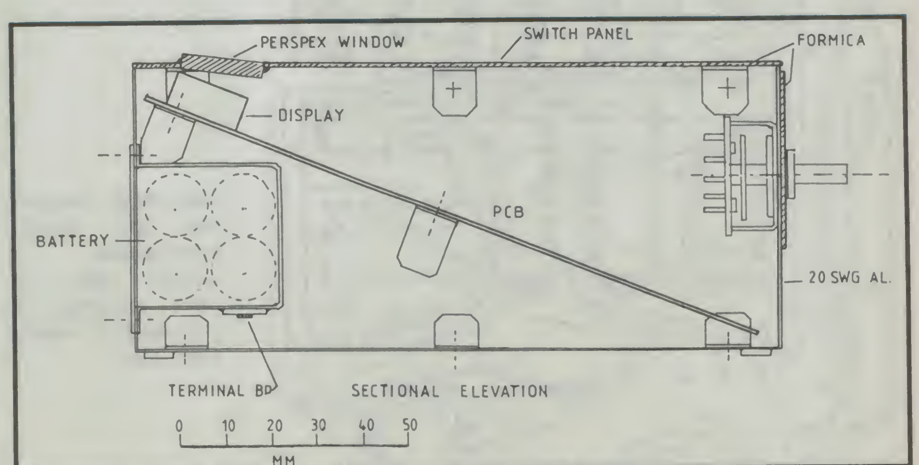
Above: Details of the author's adaptor for measuring the speed of a camera shutter. The tube needs to be opaque to light.

second clock output, reference "M" on the wiring diagram.

20 swg aluminium sheet was used for the author's case, the box size being 142 x 98 x 62mm depth. Screws are self tapping, #4 x 5mm.

A strip of metal 62mm wide is bent into a rectangle of the above dimensions, the ends butting at the centre of the near end. Use high strength Araldite to cement a 58 X 25mm lap vertically over the joint, on the inside, to provide strength.

Note that the length of this lap piece is less than the height of the box, so that it can clear the bottom which will fit within the rectangle formed by the sides. Angle pieces, three per side are



A detailed drawing of the author's case construction, to scale.

Super Timer

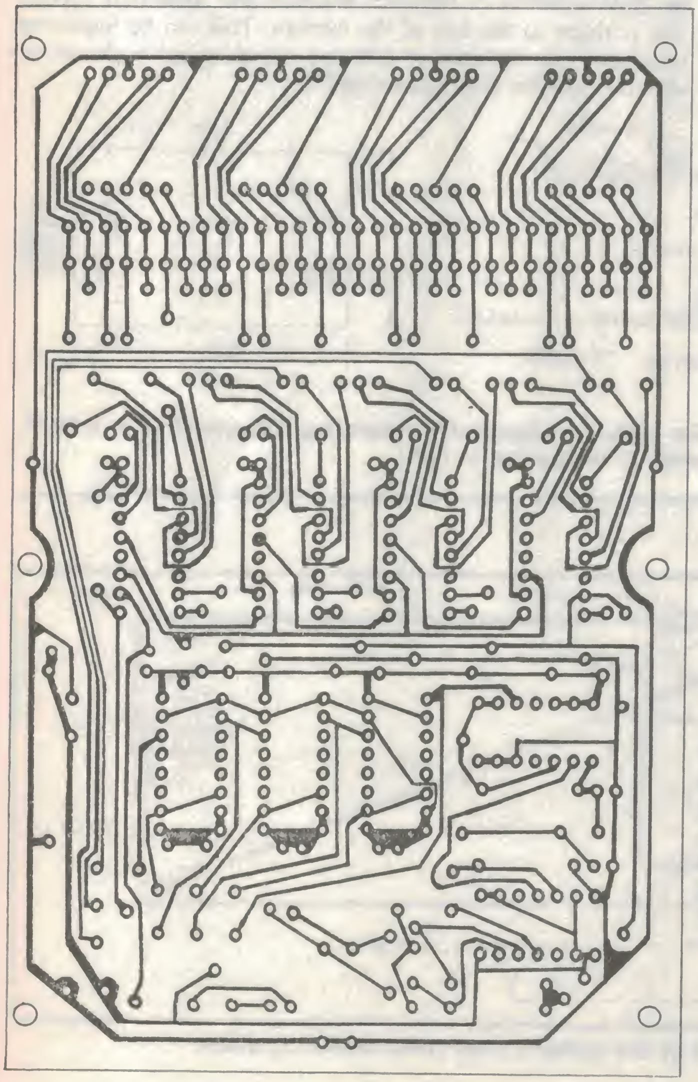
cemented to the sides with the bottom in position so that when finished the bottom is flush with the sides. Allow 24 hours for the cement to harden, then drill and fasten. Attach rubber feet, such as discs cut from an old inner tube. These should be thicker than the screw heads.

The front panel was made from a piece of white matt Formica veneer which readily accepts lettering, and has an attractive appearance. Cut to the exact dimension of the box, mark out and drill for the switches, using a small square file to form rectangular openings where slide switches are used. Don't cut out for the display at this stage.

Fitting the PCB

It has been mentioned that by fitting the board in an inclined position, a very compact arrangement can be achieved. To do this, lay the box, with bottom removed, on its side, and place the PCB on edge in the box, with its lower end against the front (socket end) and resting on the bottom if this were in place. The top (display) end of the board should be located so that the top edge of the display is about 2-3mm below the lower surface of the panel when fitted. Wedge the board in position, and with a pencil mark the position of the under surface of the board to each side, and mark the position of the upper and centre mounting holes of the PCB. The lower holes will not be used as they will not be accessible with wiring in place.

Make four angle pieces, 10mm wide. The side of the angle which is to be cemented to the box should be 20mm long, to give adequate gluing area. The other side, which is to be drilled for mounting the PCB, should be just long enough, but not so long as to bridge any track on the PCB. It doesn't matter if it contacts the 0V track at the outer edge of the board. You can trim up the length of each bracket with a file later, if you are careful. When the cement is set, drill tapping holes in each bracket and fit the PCB temporarily.



The PCB pattern for the timer, reproduced actual size to allow tracing if you wish to make your own.

Display window

With the PCB in place, lay the panel on top of the frame and transfer the position of the display to the top of the panel. Allow for the fact that the display will probably be read from an oblique position and the window should be deep enough to allow this. In the project as made, an opening 75 x 18mm was satisfactory.

The opening can be filled with some clear plastic, or, to provide a nice touch, use some thick clear acrylic, 4-5mm thick. Cut it to be a push fit lengthwise in the opening and tilted so that its lower back edge is flush with the underside of the panel while its upper front edge is flush with the upper face of the panel.

With the panel inverted run a thin line of Araldite along each of the sides, but be careful not use enough to be visible from the top. With the transparent cover at a similar angle to the PCB there is a particularly good view of the display.

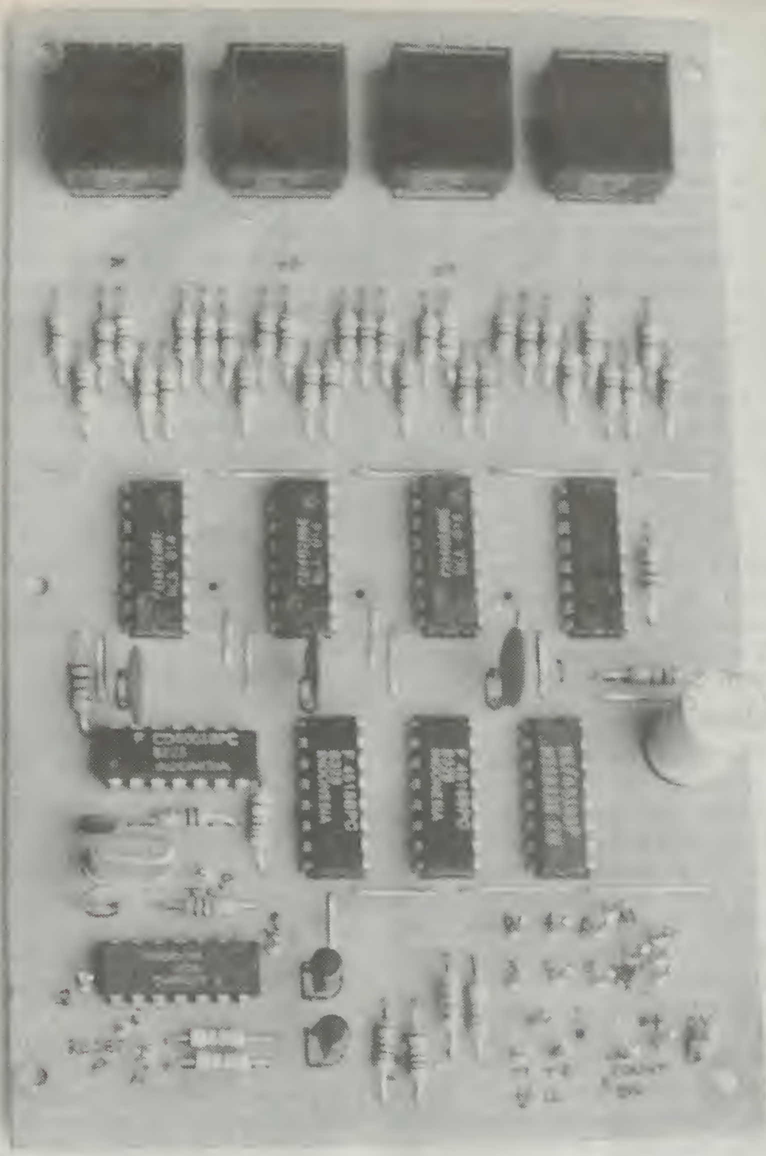
Fitting the panel

Drill three tapping holes on each side of the surround, 4mm down from the top edge. Now place the top panel face down on a sheet of paper on top of a solid surface, and place the surround over it, positioning it very carefully so that the panel is completely covered. Use weights to hold it from shifting.

Make six aluminium brackets, 15 x 15 by 20 width. These are to be glued to the PANEL. Cover one face of each angle with cement and position carefully on the panel, making sure that each angle is centered over its respective hole in the sides of the surround. Don't use excessive Araldite, otherwise it is likely to run on to the side pieces. Or worse still, if you haven't used a sheet of paper, you may find the whole thing firmly attached to the mahogany dining table.

Make sure that each bracket is pressing closely against the side walls. Check that there are no unwelcome glue attachments, and give plenty of time to set. With the panel in place, use a tapping drill to mark the position of the hole on each bracket, then finish drilling while holding the bracket in the vice to avoid undue strain on it. Now open the holes in the sides with a clearance drill. Voila!

Although not absolutely necessary, the white Formica used for the top panel makes a nice overlay for the end of the box containing the rotary switch,



A look at the PCB with components added, to help in assembly. Sorry for the fuzzy shot, but it's all that the author could provide.

and makes labelling easy and effective. Cut a piece of Formica a few millimetres smaller than the end of the box, mark if for switch and sockets and clamp it to the end of the box. Then drill through the two parts. It is not necessary to glue the panel in place, and the components will hold it in position.

Battery compartment

Note that the following relates to the use of a four AA holder with the four cells in a square configuration.

At the display end of the box, cut a rectangular opening with its lower edge about 7mm from the bottom of the box. The height of the opening should be 2-3mm greater than the battery holder with AA cells in place, and longer than the holder by about 15mm.

Make up a small four-sided box from aluminium (don't bother to join at the corners) into which the holder will fit neatly as regards height and depth. When making the box allow sufficient depth to bend a flange of 5mm on all four sides, and drill a largish hole in the back at one end for the battery leads.

When the box is made, fasten the PCB temporarily in place and make sure that when the battery box is in position there will be at least 3mm clearance from the printed circuit. When ready, cement the box flanges and clamp it to the frame until set. A cover plate completes this part of the operation.

On the underside of the battery box glue a small 2-way terminal board, on which to terminate the leads from the battery holder, and from which heavier flexible leads will be taken, (a) the positive lead to one side of the panel ON/-OFF switch, and (b) the negative lead to 0V on the PCB. These leads can be taken through the small gap between the side of the PCB and the box sides, or, if preferred through small holes drilled through the PCB.

Note: If Araldite is used where suggested, prepare the surfaces before cementing by scoring a criss cross pattern with a sharp pointed file, or coarse sandpaper. If properly carried out the aluminium will bend before the joints give way.

Wiring

First check the PCB tracks for shorts and discontinuities, and fit PC pins at +6V and 0V points. Solder in all the links, with a temporary link at LX (see above). Put power on and check with meter or buzzer that power exists between pin 16 and the 0V pin of each IC position. Now solder in resistors R1-R31, noting that R1-R3 should be 1k. Fit the four displays and with a 330 ohm resistor (for safety) in series with a 6 volt supply, connect the 0V lead and run the positive lead along the bottoms of the resistors, checking that each segment of the display lights as its associated resistor is energised.

Now solder in IC6 and power up. If all is well, display No 4 should show a figure, usually a "0". Carry on fitting IC7-9, testing at each stage to see that each display lights up. Systematic progress checks like this can save an awful lot of strife at the finish.

Fit all the remaining resistors and PC pins at "W", "X" and "Q". With power ON, ground "X" and introduce a few positive pulses at "W". The display should show a reading. Then touch "Q" with a positive test lead – the display should reset to zero.

Assuming everything is normal up to this point, the oscillator section can be commenced by fitting IC2, C2 and C3, and the 1MHz crystal. Unless you have access to an oscilloscope or a frequency counter, it will be difficult to determine if the oscillator is running.

Take a temporary lead from pin 10 of IC2 to PC pin "W", power up and ground display enable "X" – the display should show 8888.

Alternatively, solder in all remaining PC pins, and the IC's 3-5. Connect "M" to "W", ground "X" and power up. The display should count in seconds. In turn, connect "W" to each of the pins "F" to "A", checking that counter speed increases at each change.

Super Timer

If all is well, mount IC1, and Q1-Q2, and connect P-N with a removable jumper. Also connect F to W and R to S (temporarily). Power up, separate P-N momentarily to reset Q1-Q2, and touch a jumper between T and V. The counter should begin counting in 1/10 seconds. Make a brief connection between U and V, and the counter should stop. The thyristors are reset by opening the link P-N for a moment.

After testing all functions to ensure that everything is OK, the unit can be mounted in its enclosure and the various switches connected, Banana plug connectors are used to bring timing and control signals into the box.

PARTS LIST

1 PCB measuring 145 x 90mm
4 AA cells (see text)
1 4 x AA holder (see text)
1 6 way 2 pole rotary switch and knob
1 momentary contact SPDT or DPDT switch
2 SPDT or DPDT switches
2 SP on/off switches
1 1MHz quartz crystal (PCB mounting)
1 on/off switch if internal battery is used.
OR...
1 panel plug and socket for external battery.
7 4mm banana sockets, and plugs to suit

Semiconductors

1 4001 quad NAND gate.
1 4070 EX OR quad gate
3 4518 dual BCD up counters
4 4026 decade counter/decoders
2 C103B silicon controlled rectifiers.
4 FND500, or similar, 7 segment displays.

Capacitors

1 100uF 16VW PC electrolytic
2 22pF ceramic
3 47nF ceramic

Resistors (0.25W, 5%)

3 x 1k (R1-R3)
28 x 330 ohms (R4-R31)
4 x 1 megohm (R32-R35)
1 x 10 megohm (R36)
1 x 22k (R37)
2 x 4.7k (R38-R39)
2 x 100k (R40-R41)
2 x 33k (R42-R43)

Miscellaneous

22 1mm PC pins solder, tinned copper wire hook up wire.

Wiring the switches

This can be pretty confusing if you don't first draw a rough sketch showing the point to point wiring. It is also much easier if several colours are used for the hook-up wire. Wiring between PC pins and the end panel can be of lightly insulated wire, as it is not subject to any movement once in place, but for the connections to the top panel, use wire with thicker insulation as it will be subjected to being squeezed into place when the hatch is finally clamped on.

If you intend switching the display, leave out link LX and solder in two 100mm leads before fitting the PCB. Make sure all PC pins are legibly lettered, and connect the most inaccessible first, tucking each neatly in place so that you don't have to reach among the wires later with a hot soldering iron.

Finally prop the top panel on edge at the height of the box and connect in the switch connections, keeping the wiring as short and compact as possible.

Accuracy

Do this check before installing in the case. Connect the seconds output at "M" to the clock input at "W" so that the display counts seconds. Temporarily connect S5 as a start-stop control, and start the clock on the last pip of a radio time signal. Exactly one hour later stop the count on the last pip. The counter should read 3600.

The timing period can quite easily be extended to, say 4 hours, when the counter should show 4400. If there is an unacceptable difference, it is possible to push the crystal frequency around somewhat by increasing or decreasing the value of C2 or C3.

The author found it necessary to increase C2 to 100pF to shift the cyrstal frequency from a frequency meter reading of 1000070 to 1000004.

Testing as described, and using 22pF capacitors as specified, there was no observable difference between the radio time and displayed time, and no adjustment was necessary. It is unlikely that the frequency of any crystal oscillator would be so far off nominal as to prejudice the value of this timer for most practical purposes.

Making measurements

At the commencement of this article, mention was made of a measurement of bullet speed (actually an air-rifle slug), as an example of the very short time intervals which can be measured with this timer. Here are the details.

The apparatus used to measure the speed of an air rifle slug comprised two identical triggering devices. Each consisted of a piece of Formica veneer 1/16″ thick, 100mm square. Alternatively, stiff cardboard can be used. It is much easier to cut out, but not so durable or rigid, and must be kept perfectly dry to avoid leakage.

A square of 80mm sides was cut from the centre of each piece, so as to form a hollow square with 10mm wide border. A piece of aluminium kitchen foil 90mm (0.001″) square, is taped centrally to each face of the Formica so as to allow a 5mm distance all round. Make sure that the foils are smooth and flat, so that they do not touch each other.

The assemblies (triggers) are mounted on a wooden or metal batten, so that they are at right angles to it, and separated by a distance of 12″ (measured as accurately as possible). Contact is made with each foil by spring clip or other means, connected to the connecting wires.

A common power supply is taken from the "T+" socket of the timer to one foil of each trigger unit, while the opposite foils are taken to T1 and T2 respectively. If the foils are spaced about 1/16″ apart, the rifle slug will bridge the two foils as it passes through.

The maker of the rifle claimed a muzzle speed of 280m/s, or 918 feet per second. To travel 12″ therefore should take about 0.001089 seconds. The timer switch was set in the "A" range to give a reading of around 1089.

The average of four tests gave a time of 1086 (0.001086sec) and this equated to a velocity of 280.8 metres/sec, or a little better than the maker's figure.

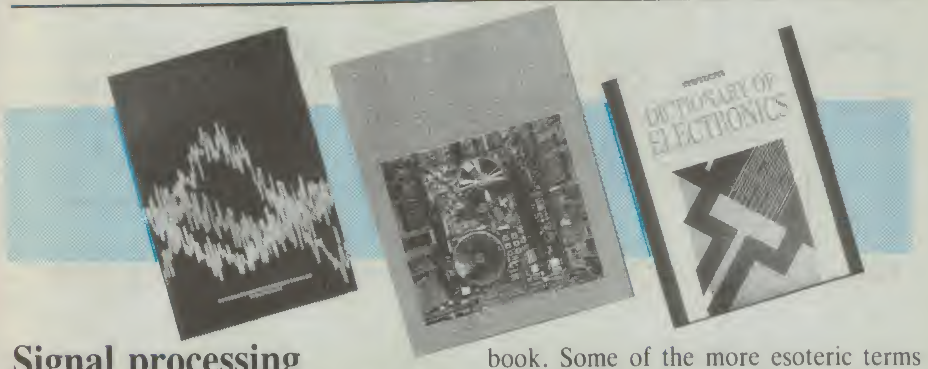
Don't attempt to clamp the trigger assembly to the barrel of the rifle, as the heavy recoil tends to cause premature triggering of the timer (probably due to air pressure on the foil as the rifle trigger and avoid physical contact between the barrel and the timing assembly. Needless to say, STRINGENT SAFETY PRECAUTIONS must be taken during such tests, to protect oneself and the general public.

The speed of a golf ball was also measured. Its probable speed was estimated at about 100mph, or 146 feet per second, so that over a distance of 3″ a measured time of 0.0205 seconds could be expected.

The timer was set to 0 – 0.09999 ("b" range), for an expected reading of 2050. The golf club was wielded by a 24 handicapper, but the ball luckily sped straight and true, giving a reading of 1987 or 0.01987 seconds. This equated

(Continued on page 137)

Books & Literature



Signal processing

SIGNAL PROCESSING, by Nirode C. Mohanty. Published by Van Nostrand Reinhold, 1987. Hard covers, 235 x 160mm, 664 pages. ISBN 0 442 26476 3. Recommended retail price $131.95.

Not a book for the light-hearted dabbler, this one. Right from the outset is dives straight into the depths of Fourier, Laplace and assorted other transforms, matrix theory, state variables and similar highly mathematical concepts. The emphasis is on systematic analysis and a computational approach to the subject.

If you're looking for an easy to understand introduction to things like signal processing, filtering and so on, this is not the one. It's basically a university text and reference, and by the look of it for those in later years at that. With my own rather faded understanding of Fourier *et al*, I found it might as well have been in Russian – and I suspect 95% of our readers would be in the same boat.

For those that do need this kind of treatment, it's being distributed in Australia and New Zealand by Thomas Nelson Australia. (J.R.)

Electronics Dictionary

DICTIONARY OF ELECTRONICS, by Ian R. Sinclair. Published by Collins, Glasgow, 1988. Soft covers, 200 x 130mm, 378 pages. ISBN 0 00 434345 10. Price $12.95

Dictionaries are a marvellous source of information, and this little book is no exception. However, they tend to go out of date very quickly, particularly if the subject is electronics – so my first check was to see just how current this one is. There were, as it turned out, very few words from my technical repertoire that weren't covered in the book. Some of the more esoteric terms such as DAT, Viatel, Centronics and others were not mentioned, but I now know what a CAZAMP is.

The book includes diagrams and briefly explains all the typical (and not so typical) terms anyone involved in electronics will encounter. The explanations are concise and free of excessive jargon.

It is my belief that anyone involved in electronics needs such a book. A beginner will find great solace in being able to look up a term without having to decode the description or ask someone else, while professionals can check their spelling and confirm their understanding of the term.

Included is a five page summary of the various symbols used in electronics. These range from Greek symbols to circuit symbols (not all are SAA standards) and this section is preceded by an explanation of the resistor colour code. Quoting an oft used expression - this book 'would make the ideal Christmas gift'. The review copy was supplied by Collins Publishers in Sydney. (P.P.)

Electronic fundamentals

ELECTRONIC DEVICES, 2nd Edition, by Thomas L. Floyd. Published by Merrill, Ohio, 1988. Hard covers, 240 x 190mm, 834 pages. ISBN 0 675 20883 1. Price (approx) $36.

There are many books covering the fundamentals of electronics, as the market for books of this kind is very large. Over the years various books have become popular, including this book's predecessor – *Electronic Devices*, first edition. The second edition, like the first, is characterised by excellent presentation, including hard covers at a soft cover price.

The book deals only with linear electronics, using a very traditional approach. A block diagram of either a radio or a TV set precedes each chapter, giving the reader the impression that the book is about these devices. In fact, these diagrams serve very little purpose, and (in my opinion) are misleading and should be scrubbed from the third edition.

The book uses the first five chapters to introduce most of the concepts and devices used in electronics, including the PN junction, the transistor, diodes and zener diodes. Discrete component amplifiers are given five more chapters, including two chapters on FETs.

The operational amplifier is very well covered, starting with the op amp as a device, followed by a wide range of applications. This way the concepts of oscillators, filters and other functions are covered. The remaining three chapters include voltage regulators, thyristors and opto devices.

Mathematical equations are used throughout, generally to a level no higher than School Certificate maths. Equivalent circuits for transistors are included, using either *h* or *r* parameters. However, the j operator is not used, and the parameters themselves are described using Ohm's Law.

Because the book follows a traditional approach, the content is fairly predictable. Those who favour a non-traditional type of text would probably suggest this book is old fashioned, even though the content covers contemporary devices. Many educationalists now believe that teaching at device level is outdated, and would therefore shudder at five chapters of discrete component amplifiers.

However, whatever your views, this book is likely to become a standard, like its predecessor. There are copious diagrams and tutorial type questions, with answers provided. The style of writing is typical of any textbook, and follows the modern trend of adopting a more friendly manner than was used in the 'matter of fact' past.

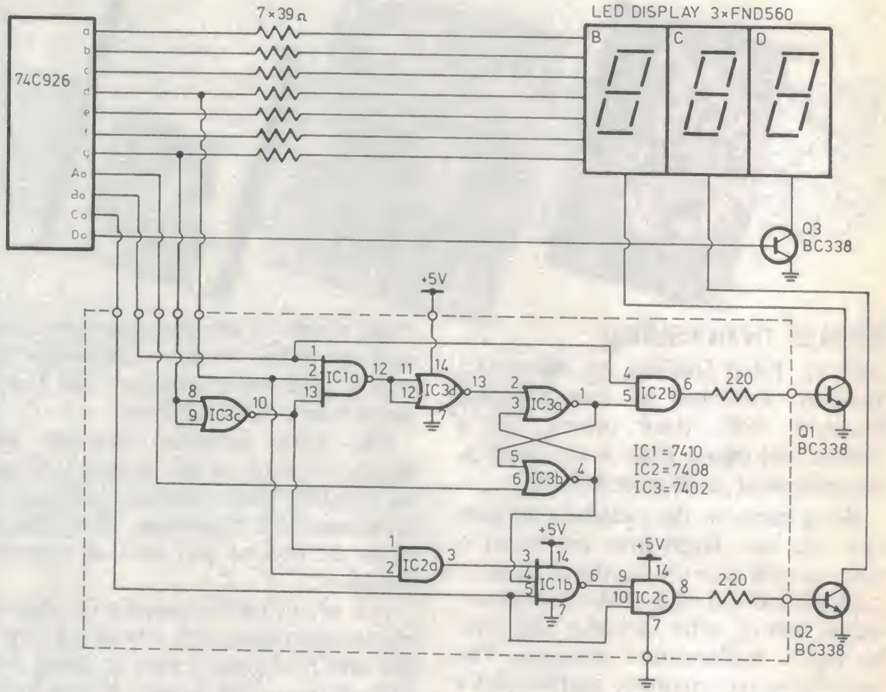
The book contains some 14 pages of Motorola data sheets, which may be found rather useless, as the devices are either out of date or unavailable in Australia. However, they provide a reference source, if nothing else.

The book will appeal to students of electronics, and possibly as a self-learn text. Because it includes a lot of self-test type questions, (as well as the tutorial type), a motivated beginner would be able to work through the book. The review copy came from Merrill Publishing Co. (P.P)

Circuit & Design Ideas

Interesting circuit ideas from readers and technical literature. While this material has been checked as far as possible, the circuits have not been built and tested by us. As a consequence, we cannot accept responsibility, enter into correspondence or provide constructional details.

Leading zero blanking



This 'add on' circuit for any 3-digit electronic display that uses a 74C926 4-digit/decoder/driver IC, improves the appearance and efficiency of the 3-digit display by automatically blanking any leading zeros.

Because the 74C926 uses multiplexed outputs to drive the 7-segment displays, it is not so easy to blank out the leading zeros. The circuit within the dotted lines operates like this:

Display B needs to be blanked when Bo and the code for numeral zero is present at the a to g outputs of the 74C926. The simplest way to detect a zero character is to sense if segment d is on, and segment g is off.

Therefore, if Bo and d are a 1, and g is a logic 0, the output of IC3d will be a 1, setting the RS latch (IC3a and IC3b) so that pin 1 (output of IC3a) becomes low. As a result, the output of IC2b is driven low, turning off Q1 and blanking display B.

Display C is blanked when Co is high, segment d is on and segment g is off. However, pin 4 of IC3b (other output of the RS latch) must also be high, indicating that display B has been blanked. If all these conditions are true, pin 6 of ICIb goes low, driving pin 8 of IC2c low, turning off Q2 and blanking display C.

Note that Q1 is held off by the RS latch, which must be reset after all outputs Ao to Do of the 74C926 have cycled once. This is why Ao is connected to the Reset input of the RS latch.

This circuit was added to an already constructed digital speedo by building it on a 30 x 65mm PCB, and mounting it behind the speedo PCB, connected with ribbon cable.

Tim Gregory,
Yarram, Vic

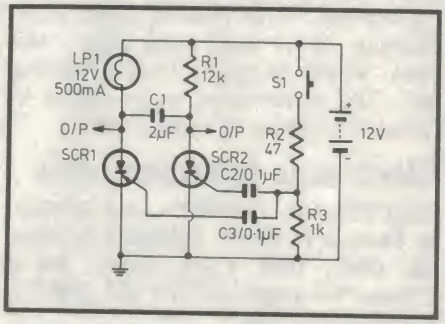
$60

One button on-off

This circuit provides, in effect, an SCR based flip-flop. The switch output(s) can be used to drive a relay or can directly interface into the circuit being controlled. The circuit works in the following way:

At power-up, both SCRs are off, giving no voltage difference across C1, as both SCR anode voltages will be at the supply voltage. If S1 is operated, both SCRs are triggered, SCR1 by C3, and SCR2 by C2. However, SCR2 will not remain on after the pulse, due to insufficient holding current, where SCR1 will stay on as it drives the lamp, L1. The potential difference between the SCR anodes will now cause C1 to charge via R1.

If S1 is again pressed, both SCRs will be pulsed, as before, but as SCR1 is already on, only SCR2 will turn on as a



result. The effect of this is to apply a reverse voltage across SCR1, caused by C1 being switched by SCR2. This action will switch off SCR1 (and the indicator lamp).

At the end of the pulse, SCR2 will also turn off due to lack of holding current, and the circuit is ready for the next operation of S1.

Matthew Victor,
Dianella, WA

$30

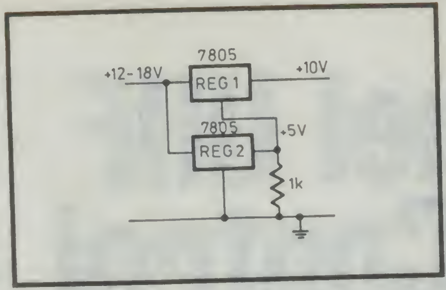
RS232 wiring tester

Working in a multi-storey laboratory with a central computer, I often have to connect various peripherals to RS232 lines remote from the computer. To minimise disruption to the system, I use the device shown in the circuit diagram to first test the lines.

The circuit tests the continuity and cross-over of lines 2, 3 and 7 before connecting the peripheral device, and consists of two parts which are connected to both ends of the line being used.

The driver unit comprises a voltage divider used to produce 9V on line 7 and 4.5V on line 3, relative to line 2. This section can be constructed in a D25 solder-tail plug and backshell, in-

Cascading regulators



Regulated voltages different to those available from fixed value three terminal regulators can be obtained in a number of ways. This circuit shows how cascading two 5 volt regulators can provide a regulated 10V supply, illustrating one possible method with which readers may not be familiar.

For applications requiring heatsinking, remember to insulate the top regulator from the heat sink, as the common lead no longer connects to earth.

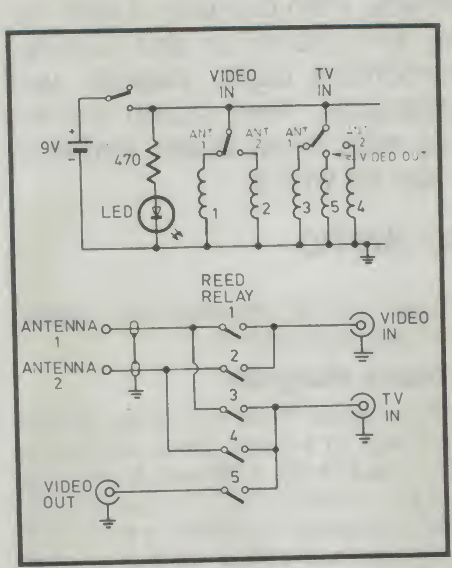
Peter O'Connell,
Oatley, NSW **$20**

TV antenna switching

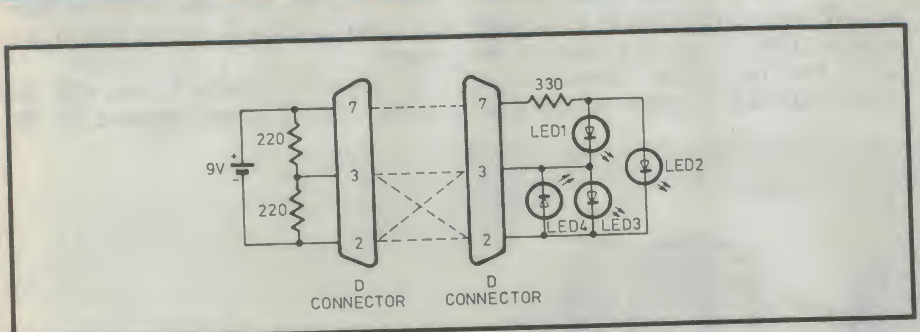
This circuit permits TV antennas to be switched without losses or crosstalk occurring. It was developed to overcome the need to swap plugs every time the video recorder was being used to record one program while the TV was used to display another. The alternative of swapping plugs was not highly regarded by the family, hence this circuit.

The circuit uses encapsulated glass reed switches, available from Dick Smith Electronics. The unit is powered by a 9V battery, which operates the selected coils to switch the reeds. The case was made of tin plate and all aerial wiring was self supporting, as thick tinned copper wire was used. The wiring was used to support the reed relays, which were spaced to minimise crosstalk.

This system could be adapted to 300 ohm cable, but the circuit shown is for 75 ohm co-ax.



Martin Elliot,
Parkville, NSW **$30**



cluding the connector for a 9V battery. I constructed a male and female version to accomodate all situations.

The indicator circuit was built on a small piece of veroboard and mounted inside a jiffy box. Four LEDs are used as indicators with a truth table on the front of the box to decode the status indicated by the LEDs. This allows decoding of straight-through or null-modem configurations and any single wire failure in each.

Again, both a male and female D plug were attached to the indicator unit for versatility. Ken Machin,
Blackburn, Vic. **$50**

Coming next month in Electronics Australia

Big Annual Digest Issue!

Yes, it's annual digest time again. Our 1989 Digest issue has 164 pages jam-packed with interesting holiday reading – including our usual rundown on the latest electronic products for industry and consumers. Don't miss it!

RGB converter

Like to be able to use an existing analog RGB video monitor with a computer designed for a TTL monitor? Here's a project which lets you do just that. Easy to build and low in cost, it also lets you adjust horizontal centring.

Audio module, PC-driven function gen.

Yes, we know we told you that these projects would be in this month's issue, but space didn't allow them to be squeezed in after all. They're now at the head of the queue, though, so expect them next month. The audio module can now produce up to 150 watts into 4 ohms, so it's well worth waiting for...

Note: Although these articles have been prepared for publication, circumstances may change the final content of the issue.

Construction Project:

16-channel UHF Remote Control - 2

As promised, here is part 2 of our remote control system. If you have built the transmitter already, then combine it with the receiver described in this article, and you're up and running. Because the receiver also incorporates digital outputs, you can start using the system immediately. Next month we will complete the whole system with a relay driver board, and then it's up to your imagination what you do with it.

by BRANCO JUSTIC

Last month we published the transmitter section of a complete UHF remote control system that has been designed for a range of applications needing remote switching. As previously described, the system features 16 channel operation, allowing the transmitter to control one or more receivers, which in turn operate up to four 4-channel relay/indicator PCBs.

Now comes the receiver, the heart of the system. The receiver is actually two sections on the one board – the UHF receiver itself and the decoding logic. The outputs from the decoder are digital, direct from a CMOS demultiplexer in fact, and are intended to operate interface circuitry that can drive the necessary relays. A suitable relay driver board will be described next month, completing the system.

Block diagram

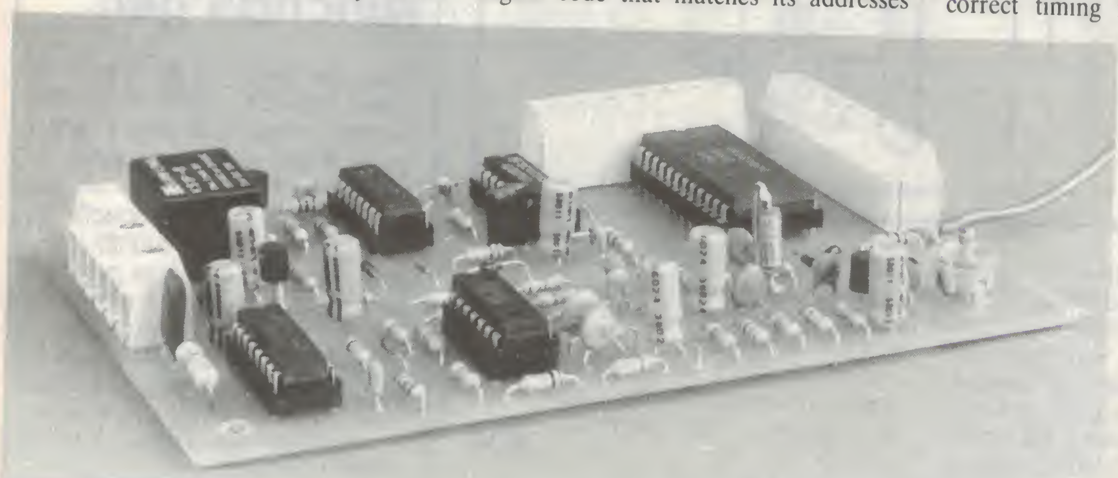
The complete 'front end' of the receiver is based on a circuit almost identical to that used in the UHF switch published in *EA*, January 1987. As shown in the block diagram, it employs a self-detecting regenerative stage which is followed by two amplifier stages, a Schmitt trigger and an inverter stage.

The digital output signal from the receiver itself is applied directly to the input of the first decoder (IC2) and via an AND gate to the input of the second decoder (IC4). If the first decoder receives two consecutive samples of a digital code that matches its addresses and timing, its valid transmission output terminal (VT-1) will go high and activate a 10 second time extender. The output of the time extender will remain active for 10 seconds even if VT-1 goes low, as would be the case if no further transmission occurred or there was an invalid transmission.

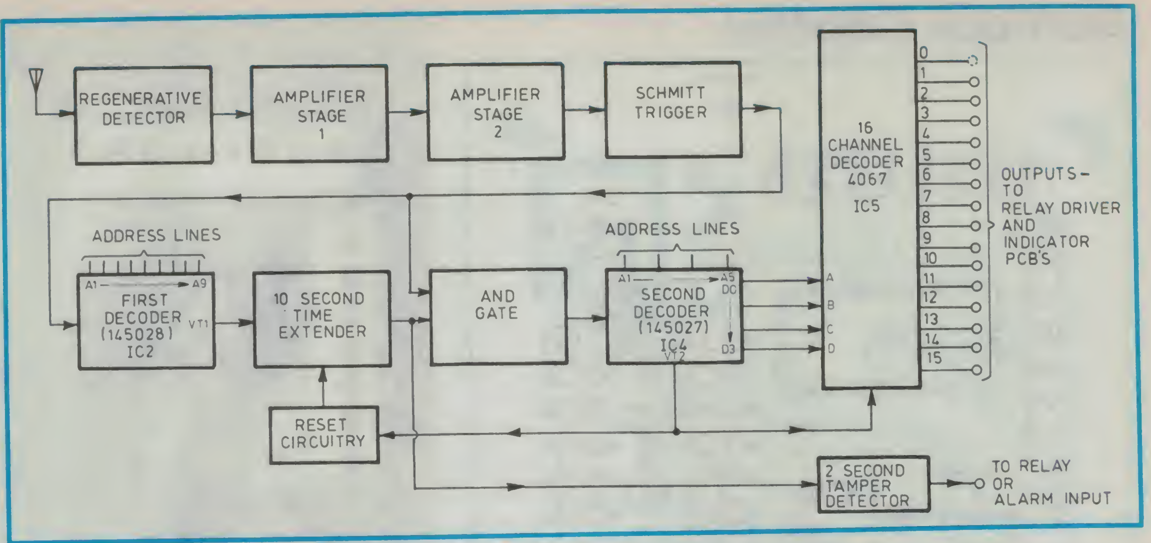
The output from the 10 second time extender activates both an AND gate and a two second 'tamper detector'. Once the AND gate is activated, the digital information present at the receiver's output can now pass onto the second decoder (IC4). This second decoder will not receive any input unless the 10 second time extender has previously been activated by a logic 1 from VT-1 of the first decoder.

Therefore, if two consecutive samples of the digital signal at the second decoder input match its addresses and timing, the last four bits of data in the transmission will be transferred to data outputs (D0-D3), and VT-2 will go high. A high at VT-2 will reset, via the reset circuitry, both the 10 second time extender and the 2 second tamper detector.

If, however, a correct code with the correct timing is not received by the



The receiver/decoder unit itself. All connections to the board are made to the terminal blocks on the PCB.

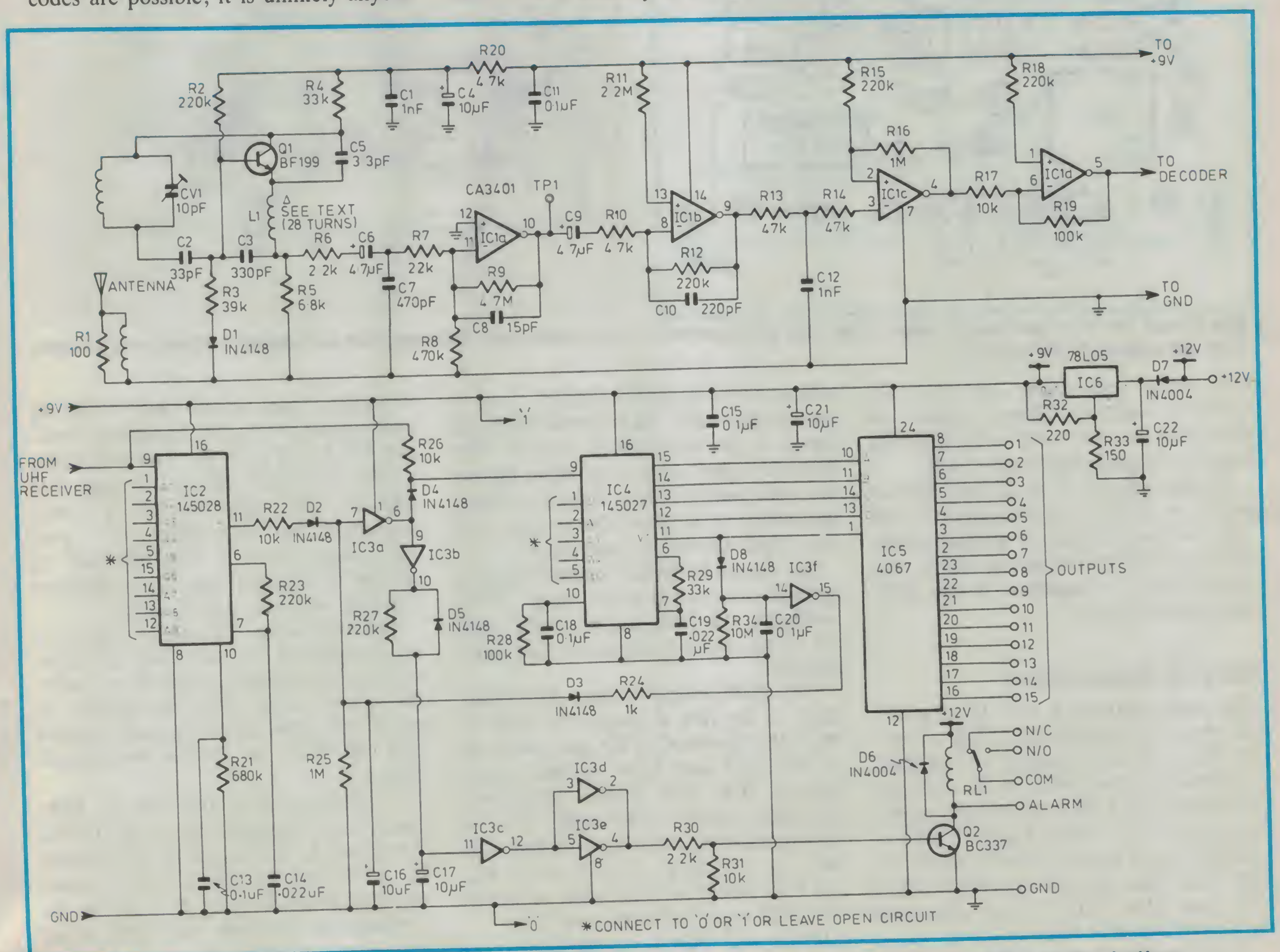


The receiver block diagram. The receiver actually comprises two sections – the receiver and the decoder.

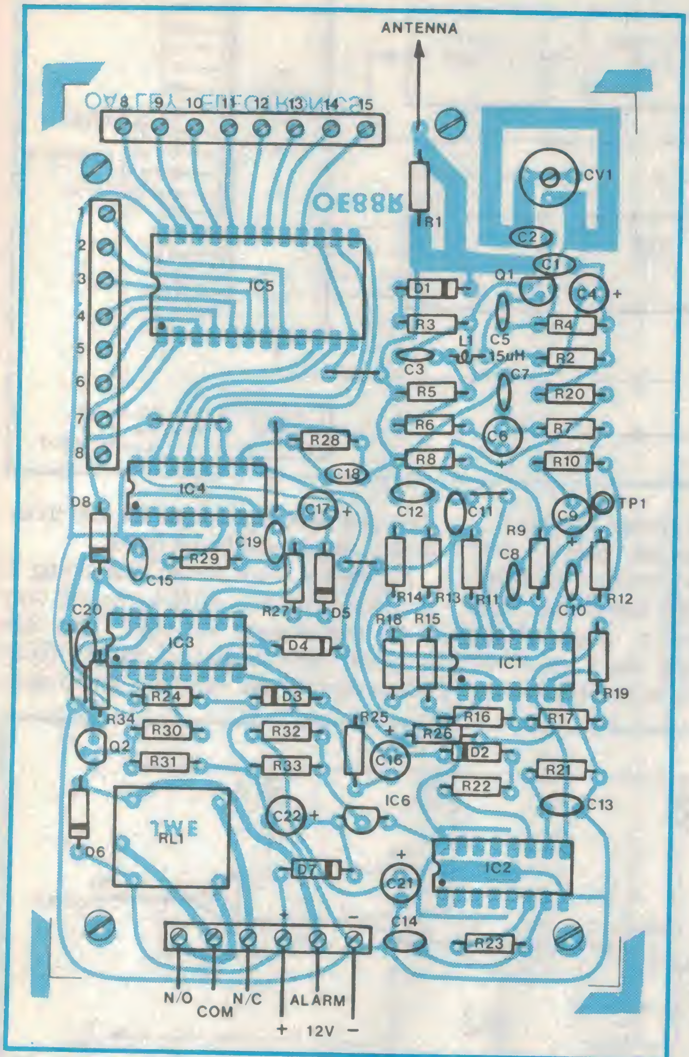
second decoder within the 2 second delay provided by the tamper detector, the alarm output will be activated. This output can be used to trigger an alarm to indicate illegal use of the system. However, because nearly 5 million codes are possible, it is unlikely anyone could break into the system anyway.

Thus, the alarm output could be used as a separate channel, perhaps activated using the January 1987 transmitter. This transmitter provided a mere 13,122 combinations – much easier to break into – but if security is not a problem, then you have a good use for this transmitter, should one be on hand.

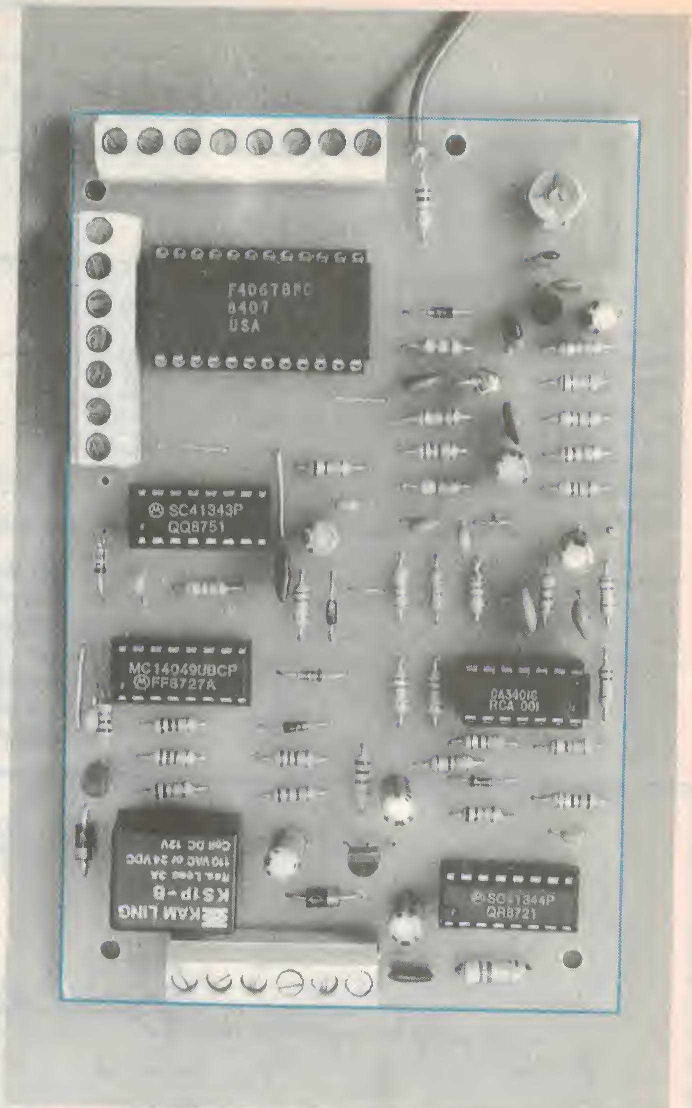
Meanwhile, back to the data sitting at the D0-D3 outputs of IC4, present only if the transmission was valid. This data is applied to a 16 channel decoder (IC5) which decodes the 4-bit data into a deci-



The receiver/decoder circuit diagram. The receiver section is shown as the top half, the decoder on the bottom.



The layout for the receiver/decoder. The unit is powered from an external 12V supply.



The prototype, showing the component placement as well.

mal value, activating one of the decoder's outputs. These outputs are then used to drive the relay/indicator board to be presented next month.

As you can see, it is virtually tamper proof, as illegal transmissions can not only be detected with an audible alarm, but the possibly of chancing on the necessary codes, in sequence, is less likely than winning Lotto.

Circuit description

The stage associated with Q1 forms a self-detecting regenerative UHF receiver. The resonant frequency of this stage is primarily determined by the inductor printed on the PCB pattern and variable capacitor CV1, which together form a parallel tuned circuit. The detected output from this stage is connected via a low pass filter (R6-C7) to a high gain inverting amplifier stage IC1a.

IC1b is also an inverting amplifier, and since its output is biased close to ground potential, the transmitted digital signal is produced at its output. The Schmitt trigger stage IC1c which follows prevents possible false digital information which could occur due to noise and low amplitude interference signals.

The output from the Schmitt trigger is applied to an inverter stage IC1d, producing the final output of the original digital signal contained in the transmission.

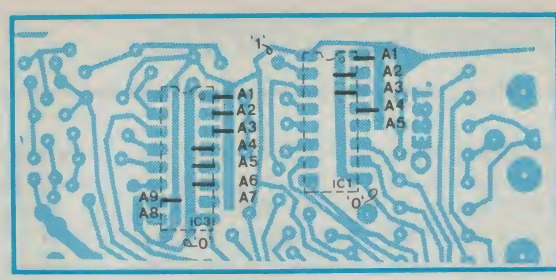
This digital output is then directly applied to the first decoder IC2, and via the rather unusual AND gate made up of R26, D4 and IC3a, to the second decoder IC4. The timing components for these decoders must match that for the transmitting encoders. In this case they are provided by R21, C13, R23 and C14 for the first decoder, and R28, C18, R29 and C19 for the second.

If the first decoder receives its correctly timed code, as determined by the 9 address lines A1-A9 and its timing components, its 'valid transmission' output VT-1 will go high. This will cause C16 to be rapidly charged through R22 and D2. This capacitor will be slowly discharged via R25 when VT-1 goes low, which gives a time constant of around 10 seconds (the 10 second time extender referred to previously).

This time delay will cause a logic 1 to be maintained at the input of IC3a, which will produce a logic 0 to enable the digital output from the receiver to reach the input of the second decoder IC4, via R26 – as D24 is now reverse biased.

If, however, VT-1 does not go high, due to no transmission, or an invalid transmission, the output of IC3a would be a '1', and the input of the second decoder would be held to a '1' by the forward biased diode D4. This would prevent the receiver output from reaching the second decoder.

Fig.1(a) – the transmitter coding. Links are connected from the IC pin to the PC tracks as shown to give the desired '1' or '0' to that pin. An open-circuit (nc) is also a valid code.



(a) System coding for IC3 (transmitter) and IC2 (receiver)									
Address line	A1	A2	A3	A4	A5	A6	A7	A8	A9
Example code	1	1	1	0	0	0	nc	nc	1
Your code									

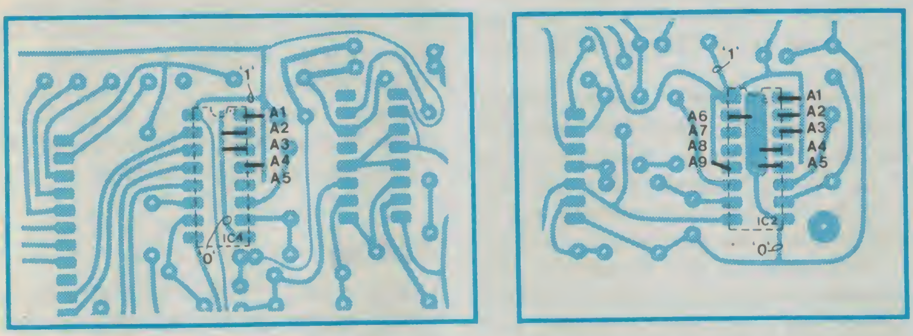


Fig.1(b) – the receiver coding. The decoder ICs must have the same code applied as that for the transmitter. Again, links are applied between the PC tracks and the IC pins.

(b) System coding for IC1 (transmitter) and IC4 (receiver)					
Address line	A1	A2	A3	A4	A5
Example code	1	0	0	1	nc
Your code					

PARTS LIST - RECEIVER

1 PCB 85 x 130mm, code OE88R
3 screw terminal strips, 1 each 6 way, 7 way, 8 way
1 12V relay
5 IC sockets, 1 x 14 pin, 3 x 16 pin, 1 x 24 pin
Enamelled copper wire and ferrite former (for L1)

Resistors

All 1/4W, 5%: 1 x 100 ohm, 1 x 150 ohm, 1 x 220 ohm, 1 x 1k, 2 x 2.2k, 2 x 4.7k, 1 x 6.8k, 4 x 10k, 1 x 22k, 2 x 33k, 1 x 39k, 2 x 47k, 2 x 100k, 6 x 220k, 1 x 470k, 1 x 680k, 2 x 1M, 1 x 2.2M, 1 x 4.7M, 1 x 10M.

Capacitors

Disc ceramics: 1 x 3.3pF, 1 x 15pF, 1 x 33pF, 1 x 220pF, 1 x 330pF, 1 x 470 pF, 2 x 1nF.
Trimmer capacitor: 1 x 2-10pF.
Metallised polyester: 2 x 22nF
Monolithic capacitors: 5 x 0.1uF
Low leakage electrolytics (RBLL): 2 x 4.7uF, 5 x 10uF.

Semiconductors

6 1N4148 signal diodes
2 IN4004 diodes
1 BC337 transistor
1 BF199 transistor
1 78L05 regulator
1 4049 hex inverter
1 3401 quad op amp
1 145027 or 41343 decoder
1 145028 or 41344 decoder
1 4067 multiplexer

When the 10 second time extender is first activated, the output of inverter IC3b is set to a '1', and capacitor C17 starts charging towards the supply voltage through resistor R27. The time constant of R27/C17 is about 2 seconds (the 2 second tamper detector), and after this time C17 will have charged to a value that exceeds the threshold voltage of inverter IC3c. This causes the output of IC3c to become a '0' and the output of the paralleled gates IC3d/IC3e to be a '1', resulting in transistor Q2 being turned on via R31, activating the alarm relay RL1.

But if the second decoder receives its correct code before the 2 second delay, the charging of C17 is interrupted, and the alarm condition does not occur.

Assuming the second decoder has received its correctly timed code, the last four digits of data received are transferred and latched at its data outputs. Also, its valid transmission terminal, VT2, will be set to a logic '1' which is applied to the input of inverter IC3f, via the time extender comprising D8, C20 and R34.

As a result, the output of IC3f is a '0', causing C16 to quickly discharge through the forward biased diode D3 and R24, effectively resetting the 10 second timer. Because of this, the output logic level at IC3b is set to a '0', allowing capacitor C17 to quickly discharge through forward biased diode D5, resetting the 2 second timer.

To activate the required channel from the transmitted binary information, a 16 channel demultiplexer (IC5) is used. This IC actually switches the logic level present at pin 1 to the selected output. Each output is selected by the input code; for example, if D = 0, C = 0, B =0 and A = 1, output 1 will be sent to a logic 1, and all other outputs will remain in the high impedance state. The logic '1' level results from the output level of VT-2 which is connected to the input of the demultiplexer.

Construction

A complete kit of parts for this project is available from Oatley Electronics. The kit is complete (as per prototype photograph) and also includes IC sockets and all terminal strips.

The only component that has to be made prior to assembly is the inductor L1. Wind 28 turns of the supplied enamelled copper wire onto the special grade ferrite core also supplied in the kit. Note that the wire can be soldered without removal of the insulation, although we suggest that both ends of the completed inductor should be tinned before it is mounted on the PCB.

Next, mount and solder all of the passive components on the PCB, keeping all lead lengths for those components

associated with the UHF receiver section (around Q1) as short as possible. Then insert all ICs into their sockets, and double check that polarity sensitive components have been correctly orientated. Also, do a final check on the track side to verify that no inadvertent short-circuits have crept in unnoticed.

Testing & adjustment

Once convinced that the construction is correct, apply 12V DC to the circuit as shown on the layout diagram. Also, connect a 400mm length of hook-up wire to act as an antenna to the point shown.

To test the receiver, use the already built and tested transmitter described last month. Place the transmitter close to the receiver's tuned circuit, and activate the transmitter by pressing any of the push-buttons. Because the receiver is very close to the transmitter, the transmission should be received, even if the receiver is not tuned correctly.

A very short press of a push-button should activate the tamper function, causing the relay to operate. However, if the push-button is pressed for around 1 second or more, causing the LED to flash a few times, the tamper function should not operate. In this instance, the output corresponding to the key code being transmitted should give a brief positive pulse, which can be detected with either a voltmeter or a CRO connected between the output and ground.

Assuming all is well, it remains to tune the receiver to the transmitter. Separate the receiver and the transmitter by 10 metres or so, and have someone activate the transmitter. Connect an AC voltmeter, in series with a 0.1uF capacitor between TP1 and ground or, if available, use a CRO set to AC coupling. Now adjust the trimmer capacitor CV1 to give maximum amplitude.

Coding

Coding is achieved by adding wire links to the appropriate address pins on the encoder and decoder ICs. A pin can either be connected to the supply voltage or to ground, or left open circuit. However, the receiver and the transmitter codes must match!

Fig.1 shows an example of how a code can be applied. Fig.1(a) shows how the example code has been implemented for the transmitter, and Fig.1(b) how the same code has been applied to the receiver. Note that links are connected to the appropriate logic level PCB track from the selected address pin.

Next month

Although the system is now operative, it remains to connect it to the outside world. This is the task of the relay driver board that will be presented next month.

You may be able to invent your own drivers, which would allow you to start using the transmitter-receiver combination. However why bother, when we have done all the work anyway.

We also plan to present a 4-channel mains appliance switching unit as well. This particular board will also include a power supply suitable for powering the receiver. We did promise a versatile unit, didn't we?

In closing, my thanks to Mr Jeff Monegal for his help in the design of this project.

Kits of parts for this project are available from:

OATLEY ELECTRONICS
5 Lansdowne Pde,
Oatley West, NSW 2223
Phone (02) 579 4985

Postal Address (Mail orders):
PO Box 89, Oatley, NSW 2223

The prices for the kits associated with this project are:

Complete transmitter kit (battery included) $34.95
Receiver/decoder PCB and components kit $59.95
Four relay driver/indicator PCB and components kit .... TBA
Four channel mains supply switching unit kit .... TBA
Post & packing charge............ $3.00

NOTE: Each kit only available after publication in Electronics Australia.

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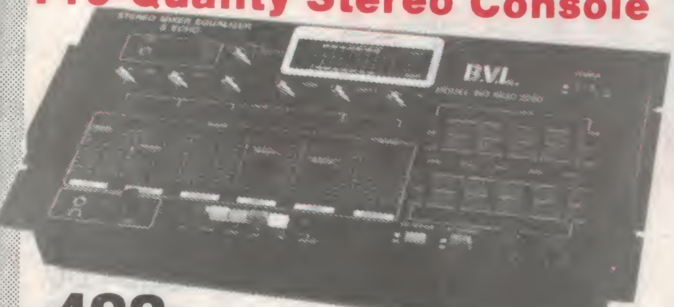
SPECIFICATIONS:
• **Input** Mic 0.5mV 600 Ohms Phono 3mV 50K Ohms Tape/Tuner 150mV 100K Ohms • **Output** 250mV • **Frequency Response** 20Hz to 20Hz (plus or minus 1db) • **Tone Control (Treble)** 10KHz (plus or minus 12db) • **Tone Control (Bass)** 100Hz (plus or minus 12db) • **Distortion** Less than 0.07% • **S/N Ratio** More than 60db • **Headphone Impedance** 4—6 Ohms • **Dimensions** 318 (L) x 217 (W) x 85 (H)

Pro-Quality Stereo Console



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SPECIFICATIONS:
• **Input** Mic 1—0.5mV 600 Ohms Mic 2—0.5mV 600 Ohms Mic 2—0.5mV 600 Ohms (low imp.) 2.5mV 10K Ohms (low imp.) Phono 1 & 2 (Mag) 3mV 50K Ohms Phone 1 & 2 (Cry) 150mV 100K Ohms Tape/Tuner 1 & 2 150mV 100K Ohms • **Equaliser** 5 frequency bands—60Hz, 250Hz, 1KHz, 4KHz, 12KHz—Boost Cut range-plus or minus 12db @ Centre frequency. • **Output** 1.5V/0.775V (Selectable) • **Frequency Response** 20Hz to 20KHz plus or minus 1db • **Distortion** Less than 0.05% • **S/N Ratio** More than 50db • **Headphone Impedance** 4—16 Ohms • **Echo** B.B.D.System • **Delay Time** 30—200mS • **Echo Repeat Control** • **Delay Time Control** • **Dimensions** 480 (L) x 240 (W) x 110 (H)

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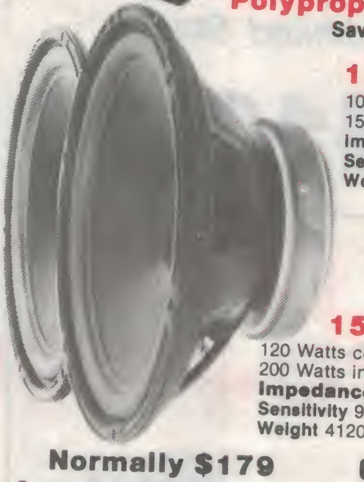

12" (300mm) Model

100 Watts continuous input
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Impedance 8 Ohm
Sensitivity 93db
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C 3070 **$99**

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The lite Guard detects a moving person or vehicle by comparing the background temperature with a rapid change of temperature across the detection beams. So when Lite Guard detects movement across the coverage area, it will turn on the floodlight(s) for 1-20 minutes as pre-adjusted.

Specifications: Detector: Dual element pyroelectric PIR sensor • Raintight outdoor all weather operation. • Photocell to deactivate sensor during daylight • **Operating Voltage:** 240V AC, 50Hz • **Operation time:** Adjustable 1-20 minutes • **Sensitivity:** Adjustable 20'-50', 30 beams • Aimable desired direction with 2 ball joints • switching Capability: 500W max. incandescent. • **Operation Modes:** Off, Auto, Test, Manual Ont.

BANKCARD • VISA • MASTERCARD PHONE TOLL FREE 008 999 007 NEXT DAY JETSERVICE DELIVERY

TOLL FREE ALTRONICS 008 999 007

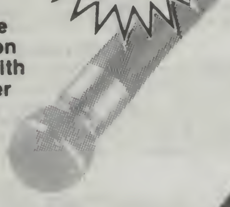
Superb *Redford* Wireless Microphone System Uses Dual Diversity Receivers for long Range, Noise Free Pure Fidelity Reproduction.

Now Available In Australia For Less Than $1,000

*Altronics proudly release the **Redford** Dual Diversity System - Used Worldwide by Entertainers i.e. Rolling Stones, Dire Straites, Tina Turner and 1000's more'*

Amazing Range of Over 200 Metres in typical applications

Superb Microphone Reproduction Compares with Shure,Beyer and AKG



Unique Microphone design completely Eliminates "Dangling" Antenna

Breathtaking performance without signal drop-out or noise interference. The Eleco Wireless Microphone System is virtually the ultimate in an Entertainers Microphone system (or for any roving microphone application for that matter!)
All the annoying wireless microphone characteristics such as "drop out", static and noise are completely eliminated by use of **auto switching dual diversity receivers.** The output of each receiver is continually monitored, with the strongest and clearest signal always selected. **Dynamic Range exceeding 100 db** is obtained by employment of a Patented special Parabola level compressor and Dynamic expander.

The operating range is a minimum of 50 metres (often this can be extended to 200 metres and more in normal circumstances).

Several Frequencies are available to aleviate cross interference when two or more systems are used in proximity.

Brief Specifications Frequency 202.1, 202.5, 203.7MHz (Please specify if you have a preference)
Mic Carrier Power 50mW (Max) **Mic Antenna** built-in **Dynamic Range** over 100db **S/N Ratio** better than 90db **Frequency Response** 20Hz to 16KHz + or - 3db **Mic Battery** 4 x AA cells **Battery Life** over 24 hours continuous operation. **Receiver Sensitivity** 12db/micro volt for 60db S/N ratio **Pre emphasis/De emphasis** 50us. **Receiver output** unbalanced 6.3mm phone jack and balanced 3 pin cannon type. **Output Level** (adjustable) Unbalanced 0-2.5V Balanced O to + or - .3V into 600 ohms. **Receiver Power Supply** 200 - 260VAC.

Prices

(A) Dual Diversity Receiver **$729.00**
(B) Entertainment Microphone (hand held type) **$349.00**
(C) Lavalier Type Microphone **$349.00**

Bonus Offer SAVE $78 Choose Receiver and Either Microphone For Just $999

Please Note 3 different operating frequencies are available (you will need to specifically nominate desired frequency only if the equipment is being used in proximity with other Systems on the 200MHz band.

Frequencies

C 0111	Dual Diversity Receiver	202.1MHz	$729
C 0113	Dual Diversity Receiver	202.5MHz	$729
C 0115	Dual Diversity Receiver	203.7MHz	$729
C 0121	Entertainment Microphone	202.1MHz	$349
C 0123	Entertainment Microphone	202.5MHz	$349
C 0131	Lavalier Microphone	202.1MHz	$349
C 0133	Lavalier Microphone	202.5MHz	$349
C 0135	Lavalier Microphone	203.7MHz	$349

AT LAST Design Quality Weather Proof Speakers And Sound Columns By *Redford*

• Rugged extruded aluminium construction • Superb powdercoat industrial paint finish • Engineered in Australia • Excellent reproduction • Superior to imports — Yet just a fraction of the price!

Wide Range Weatherproof Extension Speakers For Your Stereo System

Great For The Back Patio,Swimming Pool, Games Room, Den, Pool Room Etc.

Dimensions 260mm wide x 170mm high x 150mm D. (Mounting brackets are included)

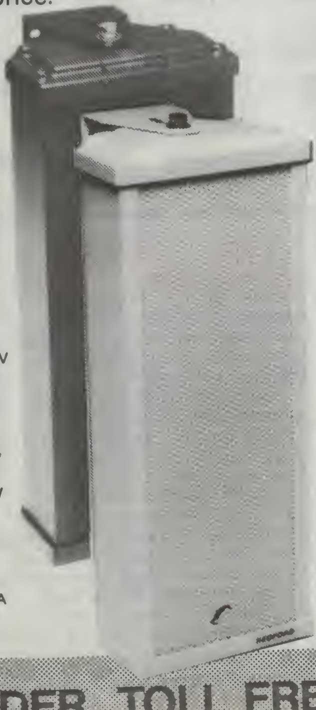
Altronics proudly announce the release of the superb ***Redford*** Weatherproof Speaker and Sound Column Range. Imagine a wide range speaker system which is highly directional and with efficiency approaching that of reflex horns!
Redford is the solution for high quality sound reproduction outdoors. The Five Models to choose from "Fill the Bill" from applications on boats to high grade paging and music entertainment installations.

RUGGED EXTRUDED CONSTRUCTION

These vibration free enclosures are constructed from die extruded heavy gauge aluminium and finished with incredibly durable industrial powdercoat enamel. The speaker ends are sealed via gaskets and tough moulded "LURAN S" UV resistant end caps. The end result is "Good Looks" together with assured rugged durability for the Australian environment.

EXCELLENT REPORDUCTION

The drivers have been chosen for wide range,low distortion, mid range "presence" (essential for high grade vocal work) and high efficiency in general. **Power Capacity** for short term use, the drivers will safely handle 150% of rated power. Acoustic wadding is used to dampen Bass resonance. **Weather Proof Construction and use of "Doped Cones"** Foam plastic and cloth is sandwiched between Baffle and Front Grill to prevent water ingress. A first for ***Redford*** is the use of a patented cone moisture repellant process for all models.



10 Watt 16 Ohm (Max 15 Watt)

Single dual doped cone driver 16 ohm impedance is employed to give a generally correct volume balance with main speakers - an added bonus is your amplifier load is kept to respectable limits!! Great for back patio, Den, Boat Deck etc.

C 0938	White	$99ea	$190 per Pair
C 0940	Black	$99ea	$190 per Pair

20 Watt 8 Ohm (Max 30 Watt)

Use 2 special dual doped cone drivers for those wanting a bit more umph!

C 0943	Black	$139ea	$260 per pair
C 0944	White	$139ea	$260 per pair

100 Volt Line Models For Use With Professional PA And Music Systems

Using a "Doped" wide range drivers and fitted with grain oriented steel line transformer. Output cable allows connection to 10W/5W/2.5W with 10 watt models, 20W/10W/5W with 20 watt models and 40W/20W/10W with the 40 watt versions.

C 0941	10W/100V line Black	$119ea	$220 per pair
C 0942	10W/100V line White	$119ea	$220 per pair
C 0945	20W/100V line Black	$169ea	$299 per pair
C 0946	20W/100V line White	$169ea	$299 per pair
C 0950	40W/100V line Black	$225ea	$399 per pair
C 0955	40W/100V line White	$225ea	$399 per pair

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'Sixty-Sixty' Integrated Amplifier Kit

(EA May,June,July '86)

Features:
• 60 watts per channel into 8 ohm loads • Very low noise on all inputs - better than CD performance • Very low distortion • Excellent headroom • Tape monitor loop • Tone controls with centre detent and defeat switch • Mono/stereo switch • Toroidal power transformer • Easy-to-build construction • Very little wiring.

Performance Specification

Power Output — 8 ohms 62W **Distortion** - Less than .0% at 1kHz. **Frequency Response** - Phono Inputs - RIAA/IEC equalisation within + - 0.5db from 40Hz to 20kHz Line Level Inputs — -0.5db at 20Hz and -1db at 20kHz **Input Sensitivity** - Phono 1kHz -4.3mV • Line Level - 270mV. **Hum & Noise** - Phono - 89db • High Level Inputs - 103db. **Tone Control** - **Bass** - + -12db at 50Hz **Treble** - +-12db at 10kHz. **Damping factor** - At 1kHz and 30Hz - greater than 80 **Stability** — Unconditional.

K 5060 **$299**

Beginner Constructors Can Build this Amplifier Kit — It looks terrific and will last you a lifetime. **Save $200 or More on comparable performance commercial units.**

"This New Amplifier offers a standard of performance far ahead of anything we have previously published and ahead of most commercial integrated Stereo Amplifiers".
"It is half to one third of the cost of an imported Amplifier with equivalent power output and performance". *Says Leo Simpson Managing Editor Electronics Australia Magazine.*

The reproductive purity of these speakers simply amazed us. The secret, of course is the DANISH VIFA Drivers. VIFA drivers are used in many top selling imported systems such as Bang & Olufsen, Rogers, Mission, Jamo, DCM Timewindow etc.

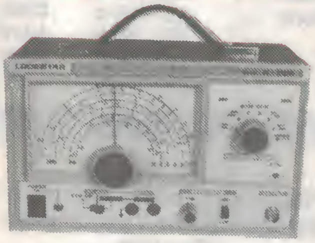
Build These Fantastic New Playmaster HiFi Loudspeakers

See Electronics Australia Sept '86

$449
full kit K 5090

If your budget won't run to the $600 to $800 needed for a fully imported pair of equivalent speakers, these are the ones to go for.

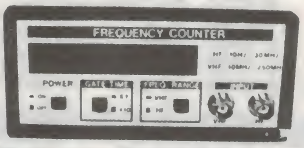
RF Signal Generator



With provision for both internal and external modulation, this generator is a winner.

SPECIFICATIONS:
Frequency Range: 100k - 150MHz in 6 ranges **RF output level** 100mV RMS **Accuracy** +/-3% **Modulation:** Internal (30% depth) - 1KHz • External - 50Hz - 20KHz • Crystal Locked Oscillator

Q 1550 **NOW $199**



Frequency Counter Sensation

150MHz Frequency Counter

A frequency counter is invaluable for the accurate alignment and testing of many modern electronic circuits.

SPECIFICATIONS:
Freq.Range: 10Kz - 150MHz
Gate Time 1 sec. 6sec. **Accuracy** +/-1 count **Max.Input** 20V P-P **Sensitivity:**
• 10Hz - 30MHz - 25mv-100mV
• 10MHz - 150MHz - 100mV - 300
• Power requirement-9V DC at 100mA

Q 1520 **$180.00**

Great Saving On Quality Solderless Breadboards

640 Holes
P 1005 **$12.50**

640 + 100 Holes
P 1007 **$14.50**

640 + 200 Holes
P 1009 **$16.95**

400 + 1280 Holes
Accepts up to 16 x 16 pin DIL IC's Terminals for PS Connections.
P 1012 **$43.50**

500 +1920 Holes
Accepts up to 24 x 16 pin DIL IC's Metal Backing Plate for Shielding of sensitive circuitry.
P 1015 **$65.00**

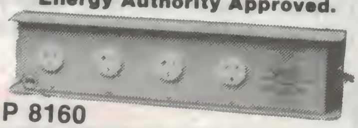
Stop Data Crashes And Corrupted Software

"Squeeky Clean" Mains Filters

An investment in one of our fantastic 'Squeeky Clean' Mains Filters could save you a small fortune with your computer system. **Protects Hardware and Software** from mains voltage spikes caused by lighting, transmitters, electric motors, welding, machinery etc. Anyone who has to re-build 3 weeks of software programming will cherish the aquisition of one of these fine mains filters.

Energy Authority Approved.

P 8160 4 Outlets
Each individually filtered. A must for 'serious' computer installations e.g. for Schools, Business etc. • **Loading Rating:** Continuous 10 amps, with circuit breaker at 240V AC. • **Outlets:** 4 GPO's individually filtered.



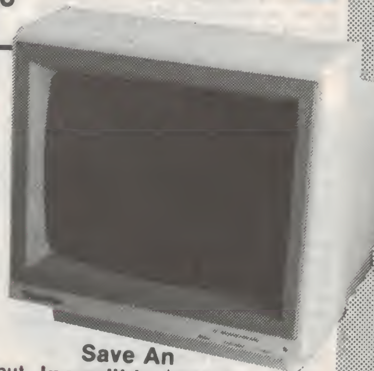
P 8160
$269

P 8150 Single Filtered Double Outlet Model
Just the shot for home computer or for individually located peripherals e.g. remote printer, computer terminal etc. **Loading Rating:** 10 Amps Max. load at 240V AC • **Outlets:** 2 GPO's single filtered.

P 8150
$99

High Definition Computer Monitor

Superb "Goldstar Pro" Non glare naturally, & screen character resolution well worthy of mating up with top end personal or professional computers.
• Compatable with IBM, Apple, Commodore Computers
• Excellent for small business applications • Exceptionally clear & stable display • 80 characters x 25 lines display. CDT Non glare phosphor P31 **Input** composite video 1V P-P **Input Conn.** RCA Jack **Input Imped.** 75 Ohms or high imped. (switchable) **Video Bandwidth** 18MHz **Horiz. Resolution** 900 lines at centre **external controls** brightness contrast



Save An Incredible $100

Now $129.00
D 1116 Amber Screen

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Just Imagine a Security/Alarm System you can install in about an hour — Uses no Wiring or Cables and Costs Less than $1 for the Mounting Hardware

UHF 305MHz Microprocessor Controlled Wireless Security System

Commercial grade, quality alarm systems are expensive - Just phone one of the "Name" security firms and get a quote for your home - our estimate is that it will be anything up to $1,000 just for the equipment - **then there is the installation** - countless holes punched through walls, miles of wiring and a day or two of installers labour and **that's around $35 per hour these days. Hardly worth the effort it it? After all what have you got to loose? - Only the Video Player CD Player, Camera, Hi Fi, TV, Jewellery and so on!!**

Well all that is now changed - with our brilliantly engineered Home Guard Wireless Security System Read On —

Take It With You If You Move

Apart from the flawless operation of the Home Guard System—One of the great features is its application with rented or leased premises—Lets face it, money spent on installing a wired system in your Home or Office, Factory etc. is irrevocably lost when you move on. With the Home Guard you simply take it with you.

This alarm system is a brand new design that features completely wireless connection to all accessories, even the reed switches. Think of how easy it is to install a "Wireless" alarm system. The benefits are endless, e.g. arming your Flat or Townhouse with an alarm you don't need to run wires through the roof or drill great holes through your walls. When moving house the alarm is simple to dismantle and re-install elsewhere.

The system divides protected areas into either perimeter zone or internal zone, programmable by dip switches in each transmitter/detector. **Pocket remote control** can simply arm or disarm your house perimeter from your bedside when retiring etc. this allows essential protection while cancelling internal zone as desired. Each transmitter/detector unit can be programmed into interior or perimeter zone. Zones can be programmed for instant or delayed trip. The system has a built-in ear piercing siren for intrusion and panic alarm signals

Passive Infra Red Movement Detector

Ideal for the lounge room, family room or hallways e.g. anywhere where an intruder is likely to pass through. Mounts up on the wall or on top of bookshelves etc. Detects movement within an area of 9M by 9M by sensing intruder body heat movement through the protected area Should not false trigger with the family cat or curtain movement etc. — as is the case with the cheaper Ultrasonic alarms.

S 5280 $129.00

Remote Piezo Siren

This unit is an optional line carrier receiver. Receives signal through 'AC' line i.e. it would ideally be located in, say, the roof space and plugged into mains power.

S 5290 $125.00

System Is Comprised Of :

Main Control Receiver

S 5265 $349

Features:

- Wireless reception of external or internal sensors or detectors.
- Selectable home or away modes for selecting internal and external arming or just external to allow movement inside the building
- Built in Piezo electric siren gives different signals to indicate different functions.
- Sends signal down power line to activate one or more remote sirens.
- Programmable Arm/Disarm switch buttons.

The main control receiver runs on 240V AC with a 12V 1.2AH battery for emergency backup. All other units with the exception of the line carrier, run on a 9V battery each. The average life expectancy is approximately one year. System works around the 305MHz frequency where there is less chance of false alarm. The range of the unit is normally 80 metres in open space.

Alarm and Indication Sounds

Intrusion Alarm — Panic Alarm — Arm Tone — Disarm Tone — Exit Click Tone — Monitor Tone — Tampering Alarm.

Complete System Special Package Price

One	S 5265	Main Controller
One	S 5270	Reed Switch
One	S 5280	Passive I/R Detector
One	S 5285	Wall control unit.

This Month $499

S 5260 Normally $570

Accessories

Note: For larger installations your system may well require several Reed switches, movement detectors and 2 or more sirens. Also the remote door controller and or pocket remote controls could be very worth while accessories. The fantastic thing about the Altronic system is you simply add more detectors as you discover the need — no wiring, no expensive technicians, no modifications to equipment.

Hand Held Control Transmitter Unit

A real joy to use — keep it at the bedside table — allows you to, say, arm the house perimeters when retiring or you can take it with you when you go out, arming your system after you lock the door. Unit is a function control transmitter — to send 4 different signals.

Off — To disarm the system before entering. **Home** — To instantly arm the system with 'Perimeter' detection only. **Away** — To arm complete system after a given exit delay time of about 40 seconds. **Panic** — To start an emergency signal whenever needed, in any mode.

S 5275 $59.00

Detector/Transmitter Unit (Reed Switch)

Suitable For Windows and Doors

This consists of an enclosed reed switch and compact UHF transmitter and a removable enclosed magnet. The unit is at rest when magnet and reed are side by side (within 25mm or 1 inch). When the magnet is moved away more than approximately 1 inch the alarm signals to the Main Control Receiver and the alarm is sounded. In practise the Reed/Transmitter is mounted on the door or window frame with the magnet on the moving door or window

S 5270 $55.00

Front Door Keypad Control Unit

This handy accessory virtually duplicates the function of the Master Controller unit but at a more convenient location i.e. just inside your entry door etc. System can thus be armed or disarmed without the need to go to Master unit. Especially handy for larger homes or offices.

S 5285 $99.00

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Jack O'Donnell
M/Director

Great Kit Projects To Build Many Just Released

Brilliant Performance Stereo Pre Amp

Studio 200 Stereo Control Unit

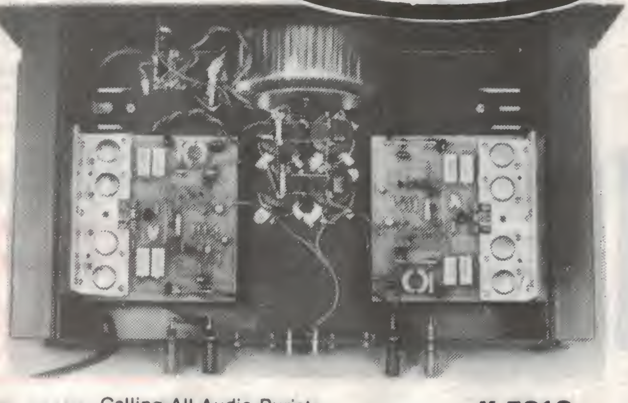
(Silicon Chip June/July'88)

Out-Performs Commercial Units Costing $600 Plus

The Studio 200 Stereo Control Unit is companion to the studio 200 stereo power amplifier (or other power amps). It features slim single unit rackmount profile, treble, bass, balance, input selector, tape monitor switch, stereo/mono switch and volume control. Inputs include phono, tuner, CD, VCR and tape loop.

K 5015 $229

Simple PCB Construction Virtually No Wiring



Calling All Audio Purists
This Great New Amp From Silicon Chip Is For You

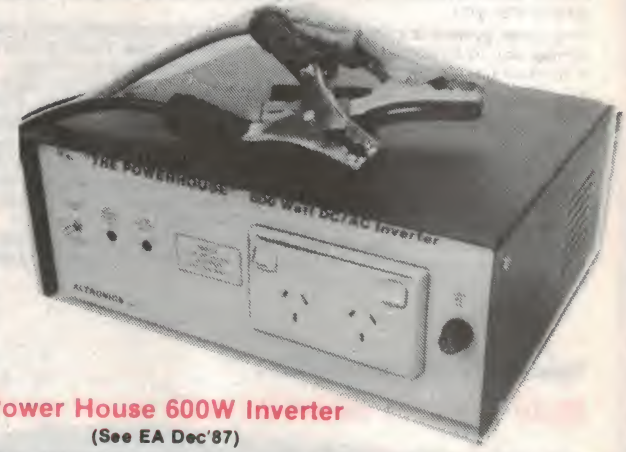
Studio 200 Series 100 Watts Per Channel Power Amplifier

K 5010 $399

Features: • In-Built speaker protection • Toroidal Transformer (low hum) • Black Satin Finish • Low leakage power supply capacitors • Housed in Rugged Custom Chassis.

Specifications: • **Output Power** 100W into 8 Ohms **Freq. Res.(at 1W) 20Hz-50KHz** + or - 1db **Input Sensitivity** 870mV **Harmonic Distortion (20Hz-20KHz)** 0.1% **Signal To Noise Ratio** 100db or Better **Protection** 5A fuses plus RDE245A Polyswitch **Damping Factor** (without Polyswitches) 100 (with Polyswitches) 100. **Stability** Unconditional.

Go anywhere 240V Mains Power from your car or truck battery with these fantastic DC to AC Inverters



Power House 600W Inverter

(See EA Dec'87)

A must for farming, camping, mining, boating, remote settlements and wherever else 240V power isn't available.

Features: Strong custom steel chassis • Industrial grade power coat finish • Can be configured to operate off either 12V and 24V DC • Very little internal wiring • Manual or Auto start facilities • Low battery cut out • Compact Toroid transformer.

Fully Built & Tested

K 6770 KIT VERSION	K 6774 12V INPUT	K 6775 24V INPUT
$425	$525	$525

300 Watt Inverter With Auto Start

Operates From 12V Car Battery

Features: Auto start draws power from your battery only when appliance is plugged in and "turned on" i.e. battery can be left permanently connected if required. • **Voltage regulated** • **Current Regulated** • **Current Overload** unit self limits — Single PC Board construction — easy to build as there is very little internal wiring.

Complete Kit
K 6750
$279.00

Fully Built & Testec
K 6755
$379.00

Discolite

(See Silicon Chip July/Aug'88)

Add Some Colour To Your Next Party

K 5805 $159.50

The Discolite Flashes party lights on and off in beat with music from your amplifier.

• 4 light channels controlled by 4 separate audio channels • Forward, reverse and auto-reversing chaser patterns • Simultaneous strobe on all four channels • Alternating light patterns • Music modulation available on chaser, strobe & alternate patterns • Inbuilt microphone for beat triggering or audio modulation of lights • Direct inputs for beat triggering or audio modulation of lights • Sensitivity control • pre-settable sensitivity levels for each channel • Front panel LEDs mimic light display.

Great For Parties, Shop displays and special lighting effects.

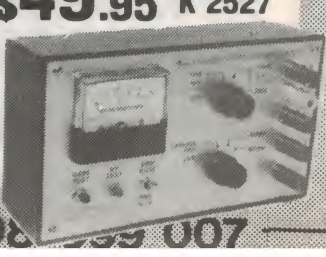
Transistor FET Zener Tester

(See EA Feb/Mar'88)

$49.95 K 2527

New updated circuit incorporates facilities for testing transistor FETs and Zeners etc.

Features: • Gain • Leakage • Breakdown Voltages • Zener Voltage • Polarity — NPN/PNP



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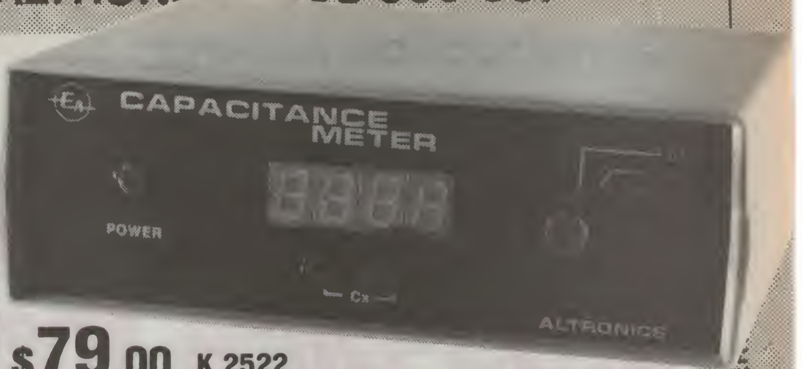
PHONEORDER TOLL FREE ALTRONICS 008 999 007

Low-Cost Unit
Checks Values from 1pF - 100uF

Upgraded Digital Capacitance Meter

The readout consists of a bright 4-digit LED display and the full scale readings for each range are 9999.9nF and 99.99uF. No adjustments are necessary when taking a reading. You simply connect the capacitor to the test terminals and select the appropriate range. The circuit can accurately measure capacitance down to one picofarad (1pF). This is made possible by the internal nulling circuit which cancels any stray capacitance between the test terminals or test leads. So when you measure a 5pF capacitor, the unit will display 5pF.

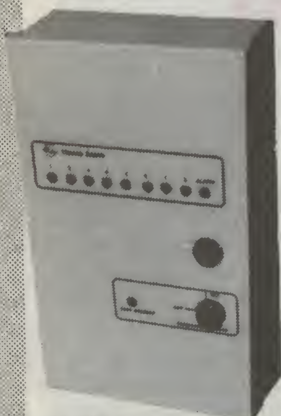


$79.00 K 2522

Save $$$ on the cost of commercial equivalents

Super Low Price on Famous EA 8 Sector Alarm System Kit

(See EA Mag.Jan '85)



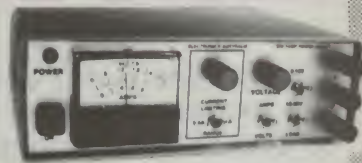
Features:

- Alarm has 8 separate input circuits - 8 sectors can be monitored independently.
- Each input circuit is provided with an indicator LED and a sector On/Off switch.
- Individual sector isolation allows the user to have some areas of the premises habited while others remain protected e.g. Inside Off/Outside On.
- Inputs accept both normally closed and normally open sensors.
- Two inputs provided with an entry delay between 10-75 seconds).
  Internal trip warning buzzer—alerts owner/occupant of pending alarm operation—great for the "forgetful" amoungst us. This buzzer is pre-settable between 5 and 55 seconds prior to Alarm.
- Unique circuit detects automatically when any N/O or N/C loops are either open circuit or dead short. **e.g. someone trying to bridge reed switches etc.**
- Switched output can be used to send a silent alarm through an auto-dialler circuit or similar.

K 1900 (without Back Up Battery) **KIT $149.50**
S 5065 (12V 1.2AH Backup Battery) **Now Only $15.00**

Bench Top Power Supply

3-30V to 1 amp Max.with variable current limit



FEATURES:
* Output 3 to 30V at 1A * Short circuit protected * Load switching * Current limiting. Dual scale meter * Housed in our Deluxe "ABS" instrument case.

SPECIFICATIONS:
* Output Voltage - 3 to 30V * Output Current - 0 to 1 amp (fully variable) * Load Regulation - Better than 0.2% from 0 to full load * Output Ripple-Less than 2mV RMS.

KIT K 3210 $79.00

KIT K 3300 $195

Laboratory Power Supply

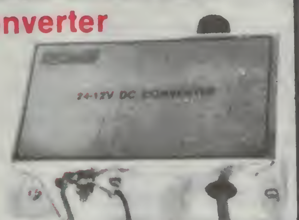
3-5 Volts at up to 5 Amps

Designed by Electronics Australia, this supply has been one of our most popular kits. Our version incorporates refinements and is now housed in an attractive, tough "ABS" instrument case. This all new compact version has been made possible by the use of a highefficiency Toroid Power Transformer. So you win four ways - less heat, less weight - Greatly enhanced appearance and easier to build - **Remember the Altronics Kit is fully drilled and punched.**

24V To 12V DC Converter

(Silicon Chip Dec'87)

Enables 12V appliances like stereos, 2 way radios, CB's etc. to operate from a 24V battery.
• Operates from 18V-30V. Output is 13.6V at 5 amps.



KIT K 3255 $59.00

Manufacturers, Contractors and Bulk Users Please Contact Our Wholesale Sales Dept.
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Perth 09 328 2199

ALTRONICS

174 Roe St. Perth W.A. 6000
PHONE TOLL FREE 008 999 007
Perth Metro & After Hours (09) 328 1599
ALL MAIL ORDERS
P.O. Box 8350 Perth Mail Exchange W.A.6000

STANDARD DELIVERY & PACKING CHARGE $4.00 to 1Kg $7 over 1Kg AUSTRALIA WIDE — We process your order the day received and despatch via. Australia Post. Allow approx 7 days from day you post order to when you receive goods

$7.00 OVERNIGHT JETSERVICE — We process your order the day received and despatch via. **Overnight Jetservice Courier** for delivery next day Country areas please allow additional 24-48 hours. Weight limit 3Kgs (3Kgs covers 95% of Orders).

$10.00 HEAVY HEAVY SERVICE — All orders of 10Kgs or more must travel Express Road - Please allow 7 days for delivery.

INSURANCE — As with virtually every other Australian supplier, we send goods at consignees risk. Should you require comprehensive insurance cover against loss or damage please add 1% to order value (minimum charge $1). When phone ordering please request "Insurance".

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Construction project:

Universal "Real World" interface for PCs - 3

Finally, here it is! Full constructional details, showing how to get your version of the Real World Interface up and running – at least in its basic form.

by MARK CHEESEMAN

As stated in the previous articles for this project, the interface may be assembled in one of two ways, depending upon whether you are going to connect it to a serial or a parallel port on your computer. Your choice of interface will determine which components are required to build the project. The parts list has been divided into three separate sections, with the first containing those parts which are common to both versions, and the other two detailing the additional parts required for either the serial or parallel version.

There are also two separate overlay diagrams, one for each version, so that there should be no confusion as to which components need to be fitted to which version.

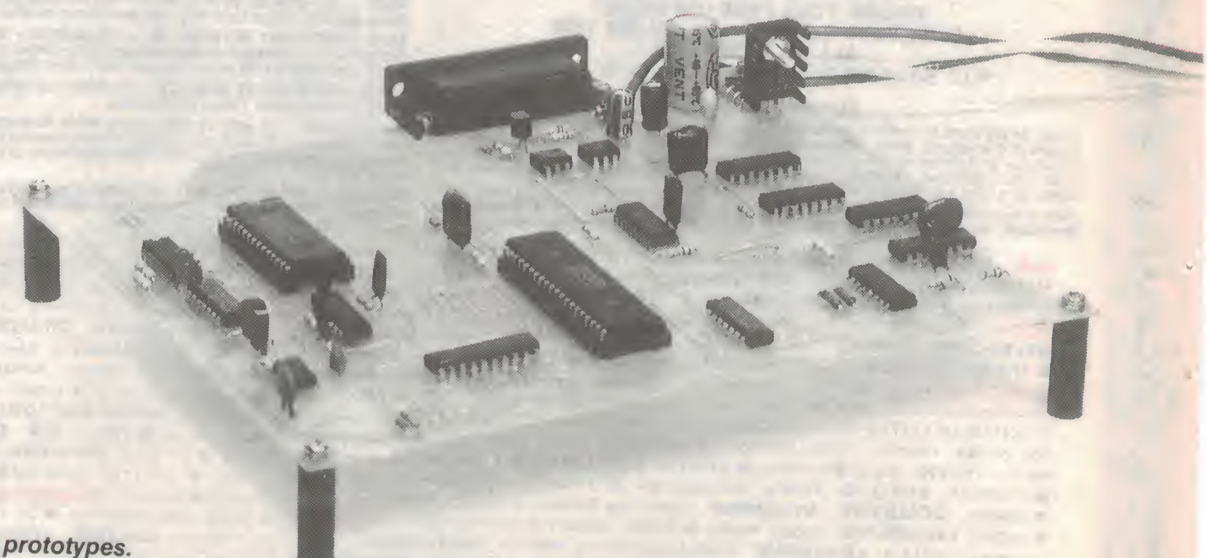
No matter which version you are building, you should first check the board carefully for bridges between tracks, and rectify any that you may find. After that, you should mount the required links on the board. There are quite a lot of these, due to the fact that we have used a single-sided board to keep costs down.

If you intend to put in sockets for the ICs, then this should be tackled next. Sockets for the large ICs (the UART and the ADC) are strongly recommended, owing to the difficulty in de-soldering such large ICs should the need arise. However sockets for the other ICs may be considered to be optional.

Next, mount the resistors, capacitors and diodes, taking note of the polarity of the polarised components. Finally, mount all the ICs, either soldering them in directly, or inserting them into their sockets if you have used them. Note that not all of the ICs face in the same direction, so watch their polarity carefully.

It is perhaps in order to discuss the choice of C5 at this point. This is the capacitor used to determine the baud rate of the serial interface and also the sampling rate of the ADC. The table of values listed in part two of this series gives values for data rates up to 9600 baud. Beyond this speed the 4N28 optocouplers start to look quite sluggish, so if you want higher speeds over a serial interface, faster optocouplers (such as the 6N138) will probably be required. However these will not fit on the existing PC board, as they have 8 pins instead of 6. C5 itself may be either a ceramic or metallised polyester capacitor, depending upon the actual value required.

If you are building the parallel interface version, the frequency of the 555 only determines the sampling rate of the ADC, and may be theoretically increased up to the maximum speed of the ADC chip, which is 1280kHz. How-



One of the completed prototypes. This one is the serial interface version.

ever you may have difficulty in getting the 555 to operate this fast. RV1 is not necessary on the parallel version, as there is no need to adjust the frequency of the 555 as accurately as is required for the UART clock signal.

Finally, mount the right-angle DB-25 connector, using a male connector for the parallel version of the board, or a female for the serial. Do not be tempted to use a connector of the wrong 'sex', as the pins will be the wrong way around, and you can be virtually assured of failure.

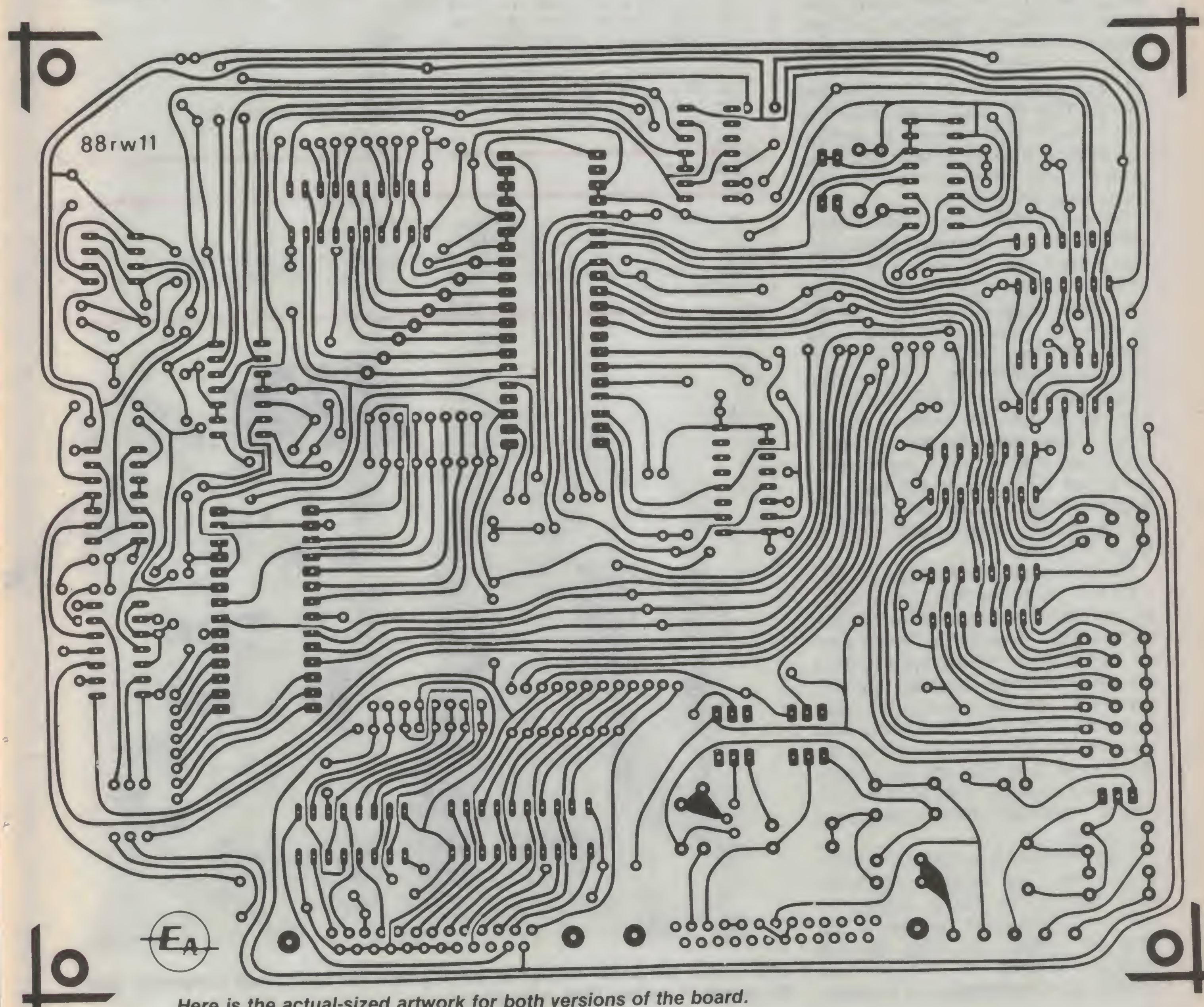
Because the serial interface is opto-coupled, the power supply for the interface board should be independent from that for the computer. Power may be obtained from any transformer capable of supplying 8 – 12V AC at 150mA or so.

For the serial version, a separate power source is also required to power the RS-232C level converting circuitry on the computer side of the optocouplers. This may be derived from a separate winding on the same transformer used to power the rest of the board, from a completely separate transformer, or from the computer itself.

The latter alternative is the most cost-effective, as you not only save on the cost of a second transformer, but can also omit D1, D2, C1 and C2 as well. All that is required is a source of +/- 9 to 15 volts DC at a few milliamps. If you intend to power the interface in this manner, the DC supply should be connected to the pads where the diodes would have gone. The positive rail should be connected to the pad marked as the cathode (striped end) of D1. The negative rail then connects where the anode of D2 would have gone.

These rails may be connected to two unused pins on the DB-25 connector in the computer, and then small jumpers added to the back of the interface board to connect the two chosen pins to the pads mentioned above.

If you cannot take the power from the computer, then you will need to either use a dual-secondary transformer to power the interface, or use a second transformer to power this part of the circuitry. While a dual-secondary transformer is the most elegant solution in this case, it may be cheaper to opt for two separate transformers, so check out the prices first.



Here is the actual-sized artwork for both versions of the board.

Real world

Testing

For this part of the procedure it would be useful to have a logic probe and also a frequency meter if you are building the serial version, although they are not absolutely vital. A multimeter would also be useful in ascertaining whether the power supply is doing what it is supposed to. First, power up the board, and check that all the ICs have power on the appropriate pins. If there is no power anywhere on the board, and the regulator seems to be getting a little hot under the collar, remove the power and check for shorts under the board.

Once any problems here have been cleared up, you can proceed with the testing proper. Two short BASIC programs have been provided to facilitate this procedure: one for the serial version of the board and one for the parallel. These programs have been written for the IBM PC and compatibles, but there should be no difficulty in modifying them to work on other computers, provided you know the addresses for the relevant I/O port.

For users of IBM PCs or their clones, and who wish to use the parallel interface version, the first step is to determine the address of the printer port that you will be using. IBM designed the PC so that no matter what address the printer interface resides at, if there is only one parallel interface in the system it will be known as LPT1: or PRN:. This means that the software doesn't have to know where the printer port is, unless you want to drive the port directly that is. If you do not know the address of your printer port, you can use the BASIC program in listing 3 to locate it for you.

Using the appropriate program (listing 1 for the parallel version, and listing 2 for the serial), progressively check all of the functions of the board. When started, the program will prompt you for a byte to send to the interface. The program will send this value to the interface, and when it receives a byte back from the board it will display it on the screen, and then send the value which you typed in again. This process is repeated continuously until the program is interrupted.

This continuous loop makes it convenient to check the inputs to the board while varying the voltage applied to them, and observe the variation in real time. Of course, the value returned when you address the outputs of the board is quite meaningless, it is merely

```
10 REM EA Real-World Interface
20 REM Serial interface test routine
30 REM Initialise COM1.
40 OPEN "COM1:9600,N,8,1,BIN" AS #1
50 INPUT "Enter byte to send to RWI"; B
60 IF B<0 OR B>255 THEN PRINT "Invalid.": GOTO 50
70 PRINT#1,CHR$(B);
80 REM wait for acknowledge
90 IF EOF(1) THEN 90
100 PRINT ASC(INPUT$(1,#1))
110 GOTO 70
```

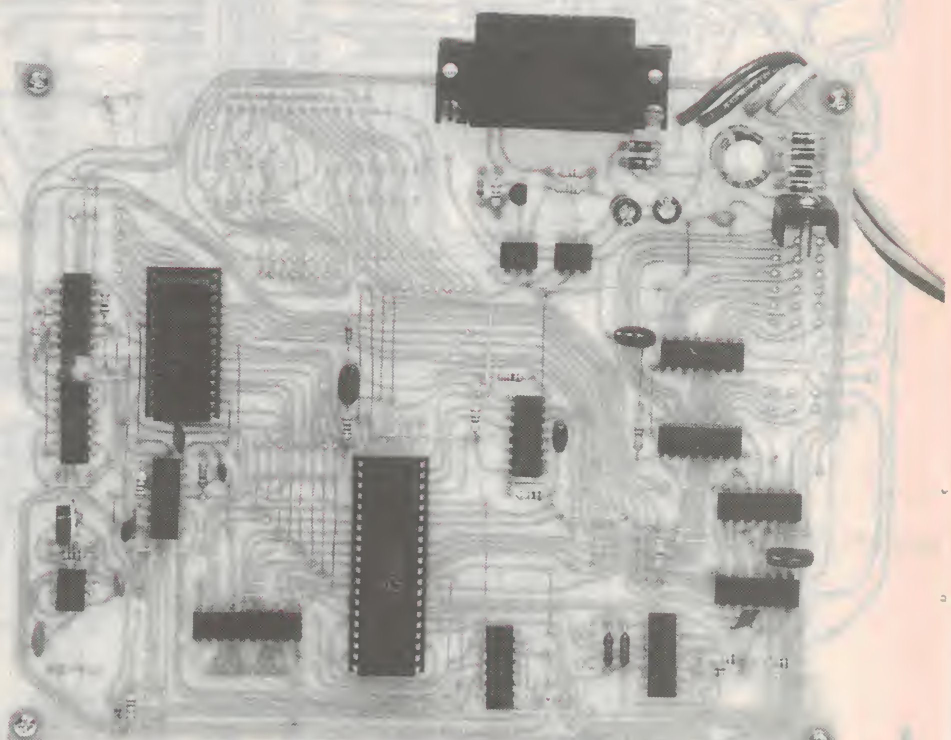
Listing 1.

```
10 REM EA Real-World Interface
20 REM Parallel interface test routine
30 BASE=&H3BC : REM Base Address for primary printer port
40 OUTPORT = BASE : INPORT = BASE + 1 : CTRLPORT = BASE + 2
50 OUT CTRLPORT,3 : OUT CTRLPORT,1 : REM Reset Flip-Flops
60 INPUT "Value to send": VALUE
70 IF VALUE<0 OR VALUE>255 THEN PRINT"Invalid.": GOTO 60
80 OUT OUTPORT,VALUE
90 OUT CTRLPORT,0 : OUT CTRLPORT,1 : REM Generate Strobe Pulse
100 TEST = INP (INPORT)
110 IF (TEST AND 128) =0 THEN 100
120 REM strobe pulse received.
130 MSNIBBLE = (INP(INPORT) AND 120)*2
140 OUT CTRLPORT,9
150 LSNIBBLE = (INP(INPORT) AND 120)/8
160 NEW = MSNIBBLE + LSNIBBLE
170 OUT CTRLPORT,3 : OUT CTRLPORT,1 : REM reset FFs
180 CLS: PRINT NEW
190 GOTO 80
```

Listing 2.

```
10 REM Parallel port locating routine
20 DEF SEG=0:AD=&H408:PORT=0
30 FOR X =2 TO 0 STEP -1:PORT=PORT*256+PEEK(AD+X):NEXT X
40 PRINT"Your printer port is at I/O address ";HEX$(PORT);"hex"
50 DEF SEG
```

Listing 3.



This is how the serial version of the interface will look when completed. Note the heatsink on the 7805 regulator.

an acknowledgement to indicate that the board got the message.

If you have built your board with a serial interface, the first thing to do is to adjust the frequency of the 555 oscillator to the correct value. If you have a frequency counter handy, simply attach this to pin 3 of the 555, and adjust RV1 until the counter reads the correct frequency, according to table 1 in the October issue.

If you do not have access to a frequency counter, there is another way to set the operating frequency of the 555. First write a program to continuously send bytes to the serial port, without waiting for any form of acknowledgement from the interface. Then run the program, and observe the status of LED1 (the framing error indicator). If this LED is not illuminated, adjust RV1 in one direction until the LED just lights, and take note of this position. Then turn RV1 the other way until the LED just lights again. Finally set RV1 mid-way between these two points. This will result in a frequency that is close enough to the correct value.

TABLE 1

Value	Action Performed
0 to 15	Write 0 to 15 to first output latch (IC7)
16 to 31	Write 0 to 15 to second output latch (IC8)
128	Read digital input latch
144 to 151	Read Analog input 0 to 7

Table 1 lists the values to send to the board to address the various parts of the board. Test each of these values in turn, checking that the screen continuously updates the display, showing the last byte returned from the interface in the upper left-hand corner of the screen. If the program appears to 'hang' at any time, this is when a logic probe will come in handy to trace the signal path through the interface.

To check the outputs, connect a LED and series resistor between each output and the positive rail, as shown in

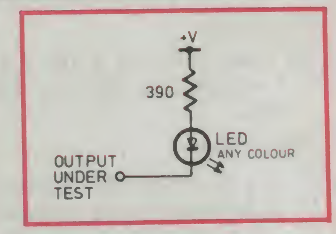
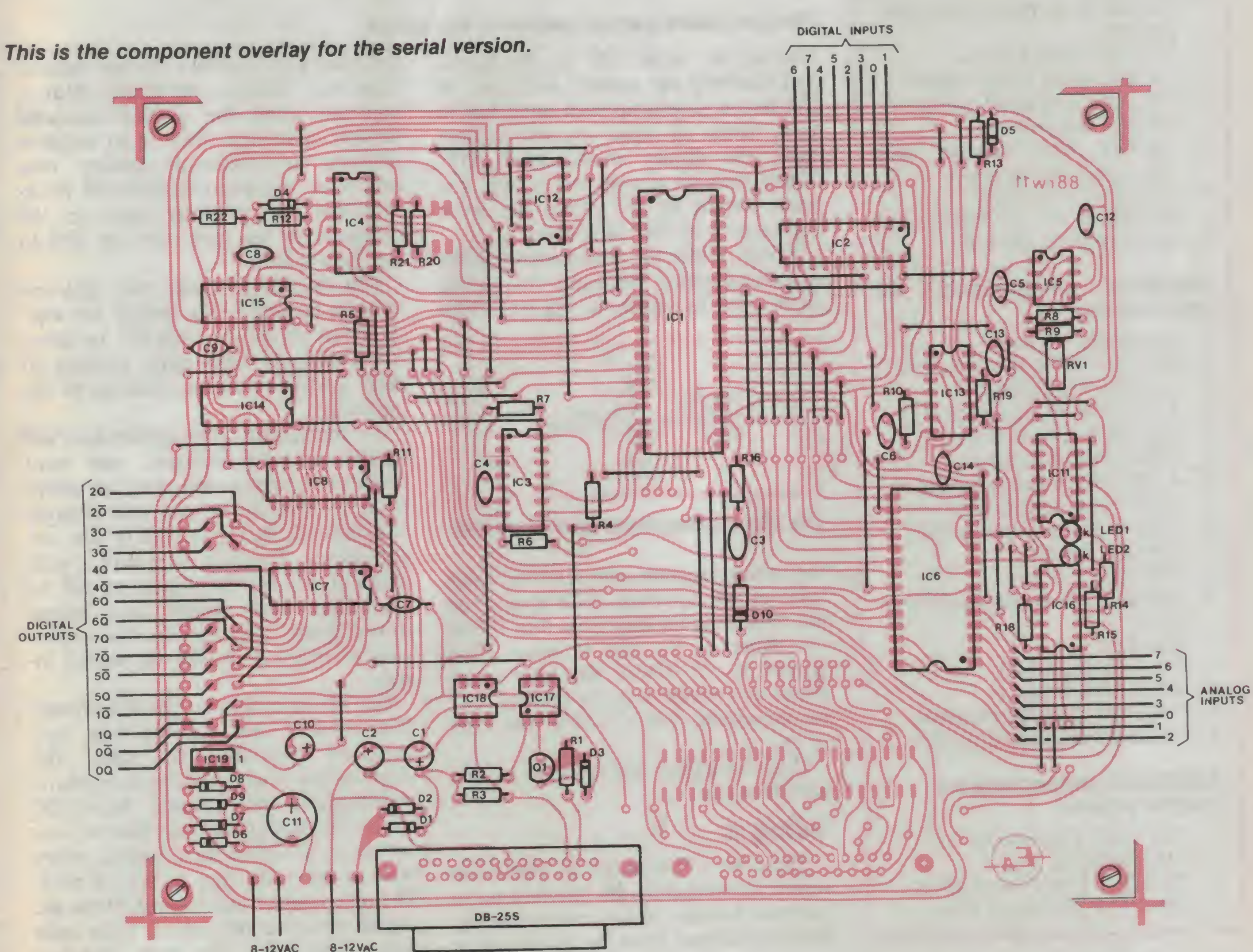


Fig.1(a). Output test circuit.

Fig.1(a). When connected to the Q-bar outputs, the LED should light when a '1' is written to the appropriate bit of the relevant output latch. Similarly, the LED should light when connected to a Q output and a '0' is written to the appropriate latch.

The digital inputs may be checked by

This is the component overlay for the serial version.



PARTS LIST

1 PCB 191 x 159mm, coded 88rw11
1 Small TO-220 heatsink
1 Power transformer (see text)

Resistors

All 1/4W, 5%: 3 x 1k, 1 x 4.7k, 1 x 8.2k, 1 x 10k, 2 x 22k, 1 x 100k.

Capacitors

2 0.1uF metallised polyester
2 2.2nF metallised polyester
1 10nF metallised polyester
1 10uF 16V tantalum
1 1000uF 16V electrolytic
1 Capacitor according to Table 1 in October issue

Semiconductors

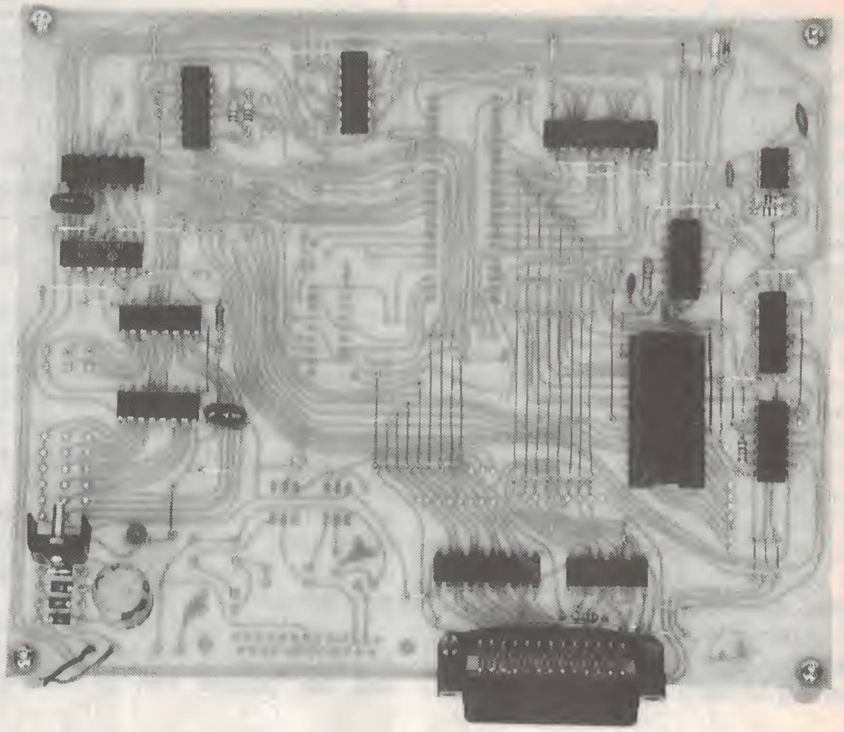
4 1N4002 diodes
1 1N4148 diode
1 7805 regulator
1 555 timer
1 74LS85 4 bit magnitude comparator
2 74LS175 4 bit latches
2 74LS00 quad NAND gates
2 74LS08 quad AND gates
1 74LS04 hex inverter
1 74LS05 hex inverter with open-collector outputs
1 74LS374 8 bit latch
1 ADC0808 or ADC0809 analog to digital converter

Additional components for serial version

1 5k vertical trimpot
3 390 ohm 1/4W 5% resistors
2 1k 1/4W 5% resistor
2 4.7k 1/4W 5% resistors
4 10k 1/4W 5% resistors
2 220uF 25V electrolytics
1 4.7nF metallised polyester
1 10nF metallised polyester
2 22nF metallised polyester
2 1N4002 diodes
3 1N4148 diodes
1 BC547 NPN small-signal transistor
2 Red LEDs
1 AY-3-1015D UART
2 4N28 optocouplers
1 74LS123 dual monostable
1 DB-25S PCB mount socket

Additional components for parallel version

1 10k 1/4W 5% resistor
1 74LS244 8 bit buffer
1 74LS257 4 bit 2 input MUX
1 DB-25P PCB mount plug



The completed parallel version of the board.

sending the value '128' to the board, and watching the number displayed on the screen as you tie each input low in turn. When all inputs are left to float high, the display should read '255'. When each bit is tied low in turn, the value should be 255 minus the value represented by that particular bit.

Finally, check the analog inputs, using a potentiometer connected to analog input zero as shown in Fig.1(b). Run

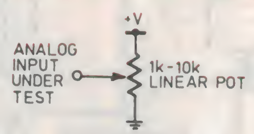


Fig.1(b). Analog input testing circuit.

the testing program, and send the value '144' to the interface. The display on the screen should vary from 0 to 255 as the wiper of the pot is swept from ground to 5V. Check the other seven inputs in a similar way, by sending '145' for input one, '146' for input two, and so on.

That completes the testing of the basic interface.

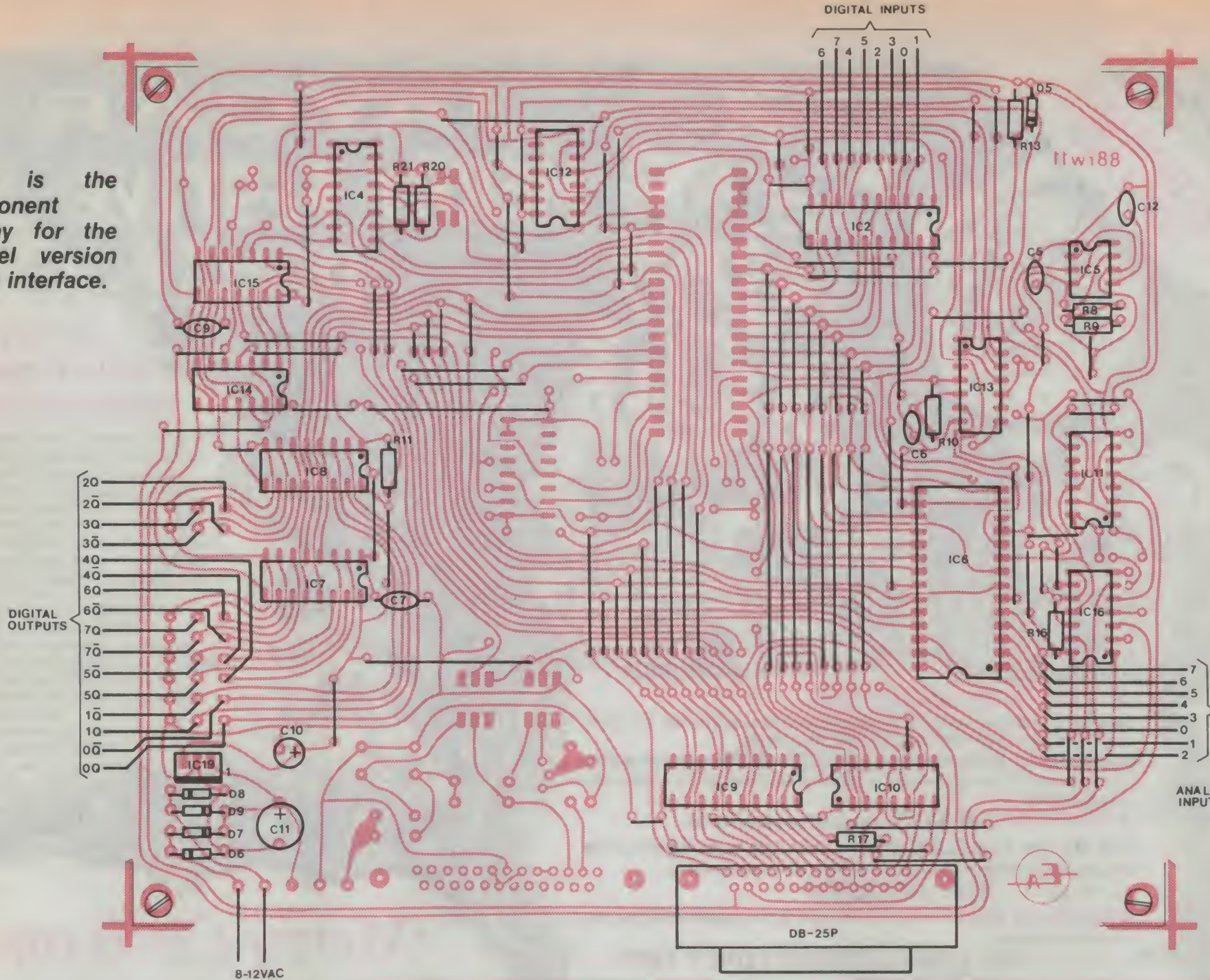
Using it

There are a few points to watch with regard to connecting the interface up to external devices. Firstly, all of the inputs and outputs must be referenced to the same point, as they are not isolated from each other on the board. Also, if you are using the parallel-interfaced version, note that there is no isolation between any external circuitry connected to the basic Real-World Interface and the computer itself, so the reference in this case must be tied to the mains earth.

You should also make sure that any voltages applied to the analog and digital inputs do not go below 0V, or above 5V. Failure to limit input voltages to these levels could cause damage to the input chip.

For this reason, most applications will require external isolation, and most likely the outputs will also be called upon to control currents and voltages well beyond the capabilities of the output latches. To allow control of a wide range of AC and DC loads, we will be presenting next month two output driver boards and also an input opto-coupler board to isolate the digital inputs.

One of the output boards will provide four separate opto-isolated triac outputs, for controlling AC loads. The other output board contains four relays, which can be used to switch AC or DC loads. The main board can then be connected up to two of these boards, either both of the same type or one of each. The opto-coupler input board allows the digital inputs to be isolated from each other, and from the main interface



Here is the component overlay for the parallel version of the interface.

board itself. This input board can accommodate up to eight opto-couplers and associated components.

We have not provided any software to drive the board beyond that used to test the board, as the intended application will have a lot of bearing on what the software has to do, and how well it must do it. For example, in many applications, BASIC routines similar to those used to test the boards may be all that is needed. However, for applications that are more dependent on speed, you may need to use languages such as Pascal, C or assembler.

For data-logging a possible, but perhaps not very obvious solution, is to use something like dBase III. This has the ability to directly manipulate the I/O ports of the computer, to control the interface, and the data can be logged directly into a database file for later processing. For applications that require the recording of large amounts of data at relatively slow rates, such as meteorological observations or say, measuring battery discharge curves, this approach will probably yield the required results for relatively little programming effort.

REAL WORLD INTERFACE PART 2 – Errata

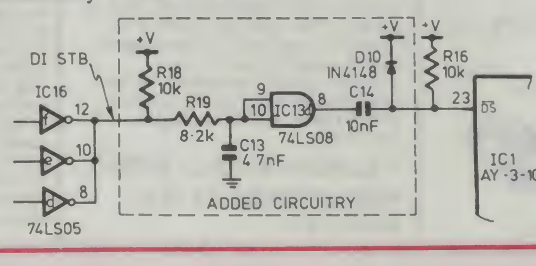
Before commencing construction of the Real World Interface, you should first note a few changes and corrections to the circuit diagram which appeared in part 2.

First of all, the two resistors connected to IC4 should be R20 and R21, not R14 and R15 as shown. Also, they should both be 1k, not 10k as shown. Also note that R6 should be 2.2k, not 100k as shown, and R12 should be 10k, not 22k. In addition, there is another resistor connected from pin 5 of IC14b to ground which was omitted from the diagram in the October issue. This resistor should be labelled R22 and is 10k in value.

The pins of IC15f, labelled 14 and 15 should be 12 and 13 respectively. Also the inverter connected between pin 22 of IC1 and C8 should be labelled IC15b, not IC15e, as shown. The pin numbers for its input and output are 3 and 4 respectively. The pin numbers for the CLK and OC-bar pins on IC2 have been reversed. That is, the CLK line should be labelled pin 11, and the OC-bar line pin 1.

Finally, a small change has been made to the circuit published in the October issue, in order to give the data applied to the input to the UART more time to settle before being strobed in. This delay circuit is inserted between the line on the internal bus labelled "DI STB" and the DS-bar input of the UART.

The extra circuitry is shown below.



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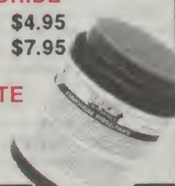
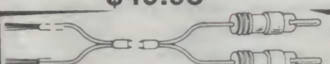


1/2 AN RCA LEAD?



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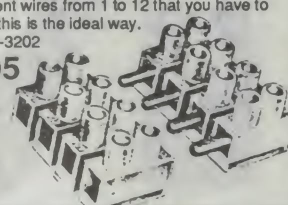

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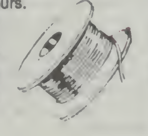

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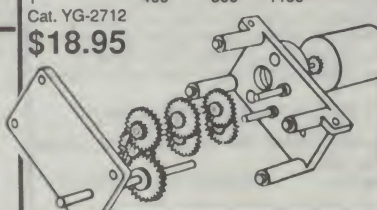
5	5	10	14
4	16	32	45
3	44	88	125
2	150	300	410
1	400	800	1150

Cat. YG-2712

$18.95



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Easy to use automatic connectors. Simply wrap around the existing wire and new wire and squeeze.

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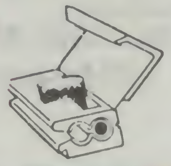


KIT'S COLUMN

Hi! Kit again.

As you know from last month, the boss has asked me to write a column about our kits - on account of the fact that I know more about our kits than anyone else!

Well, last month I told you about our fantastic Plasma Discharge lamp/display as featured in "Silicon Chip" mag for August this year. Another incredibly popular kit has been the stereo "Mini Mitter" described once again in Silicon Chip October. Demand for this kit has really kept us behind in our work! We are very proud of this kit. It is supplied complete - down to the last screw. . . .

Gossip Dept: Well, the other day the boss took delivery of his new red German toy. (The ashtray in his Lamborghini was full & he had to trade it in). He had his new car for less than 24 hours before someone ran right up his - - - - when it was parked in the street at night. (**Where** and **why** he was parked he's not saying!) He is **so annoyed** his face is a deeper colour of crimson than his new car!

If only Silicon Chip had invented the Car Safety Light (this months SC) earlier! It's a great new gadget that you fit in your car. When your car is parked alone at night in the street it detects an oncoming car's headlights and turns the parking lights (or brake lights) on for 5 seconds, so they can see the car.

Poor boss, you should see him driving the company delivery van home every night while they fix his toy!

Finally, I've really got to tell you about the effort the girls in the Kit Dept. put in. We work in really cramped conditions and the boss is always on our backs to work harder, and boiled lollies are **not** enough compensation!

So we think its worth the trip from your place to our (not **my**) place to get a quality product. If you are not happy with any of our kits, write to me **personally.**

In the mean time, keep your iron hot, and I hope that Santa Claus gives you everything you want. . . .

Kit

Digital Signal Processing:

A DSP Primer

Although digital signal processing is fast becoming the 'hottest' growth area in electronics, it's still something of a mystery even to many people working in the industry. Here's an explanation of the basic concepts of DSP, and a look at some of its applications...

by TED DINTERSMITH
Analog Devices, Inc.

Digital signal processing or *DSP* means the processing of 'analog' signals using digital techniques – i.e., digital hardware and software.

It should perhaps be noted here that *any* electrical signal is by nature an analog signal, even if it represents a digital '1' or '0'. This can be understood if one pictures what happens to a chain of 1's and 0's returned from beyond the orbit of Jupiter, buried in cosmic noise: the signal must be received, amplified, converted and processed (digitally) to reconstrt the original digital information; but until that digital information has been identified, the signal is to all intents and purposes a purely analog one.

While *any* digital processing of signals that originate in the analog world, and have at some point been converted into digital form, would qualify for this broad definition, the term DSP has come to be used in a much more specific way. Nowadays, DSP is the the application of fast, specialised hardware, sophisticated algorithms and the appropriate software for the purpose of manipulating large amounts of data associated with extracting and processing analog-based information in essentially *real time*.

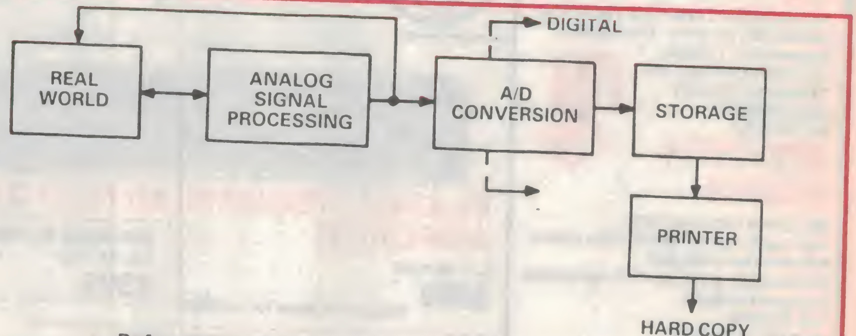
The emergence of DSP hardware is changing the role of analog-to-digital conversion in today's signal processing systems. In early days, all processing of a signal, with the goal of obtaining results with sufficient speed to be useful in real time, was of necessity handled by analog components. The principal destinations for analog signals converted to digital format, after substantial analog processing, were off-line computation, data storage, and hard-copy tabulation, rather than real-time instrumentation, computation, and control.

Now, however, system designers have an incentive to perform the signal conversion as early in the loop as possible (see Fig.1). The reason for this is that much or all of the required signal processing can be handled by fast, flexible digital components that allow high-performance DSP routines to be implemented more accurately, reliably, and flexibly than with analog circuitry, yet, in many cases, with sufficient speed to interact in real time.

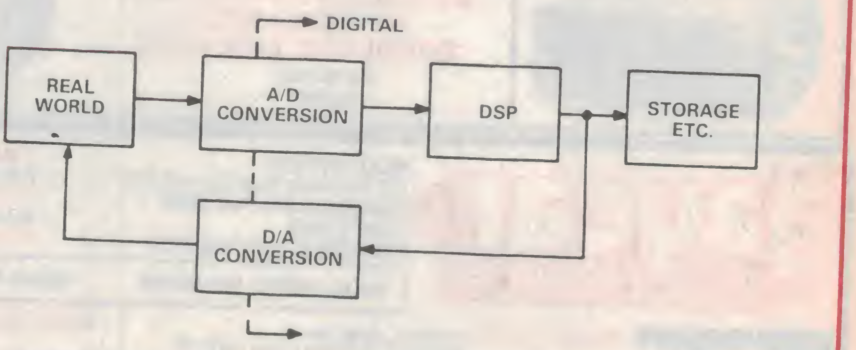
This article first reviews basic signal processing tasks, giving emphasis to the general role played by DSP. Two key DSP algorithms are examined in some detail – digital filters and spectral analysis. The basic hardware required to perform DSP is described. Finally, some applications that exemplify DSP's advantages are reviewed.

DSP basics

Signal processing revolves around two basic tasks – digital filtering and spectral analysis. *Filtering* smoothes, removes noise from, selects particular signal components from, or predicts future values of an incoming signal. A time-domain signal can be interpreted as a weighted combination of purely sinusoidal spectral components; *spectral analy-*



a. Before DSP: digital used principally for record-keeping.



b. DSP era: digital responds to and operates on real-world phenomena.

Fig.1: As DSP technology has developed, designers have been able to convert to digital earlier in the signal processing chain.

sis determines the weights corresponding to each frequency in the spectrum.

Signal-processing applications span many areas, including speech analysis and synthesis, telecommunications, instrumentation, radar and sonar, and – using multi-dimensional techniques – graphics and imaging. For example, filtering is used to minimize high-frequency noise and the low-frequency hum in telephone-line transmission. Spectral analysis is used to determine the format content of incoming speech for recognition. Two-dimensional filtering improves the clarity of a satellite image.

Filtering and spectral analysis have traditionally been implemented with analog components. Filtering is carried out by passing the signal through a circuit consisting of resistors, capacitors, op-amps, and/or inductors; the precise configuration of these components and the relationship of the magnitudes of their parameters determine the filter's characteristics. Multiple analog filters – each passing energy in a narrow band – can be cascaded for sharpness and banked together to perform spectrum analysis.

Analog-based signal processing has numerous advantages, including low component cost, the ability to handle wide bandwidths in real time, the availability of pre-packaged modules and ICs, and a large existing base of knowledge. However, analog components introduce noise at each stage; and filter characteristics – requiring effort to tune initially – are sensitive to the effects of temperature and aging. In addition, multi-stage filters pose subtle design challenges. Because coefficients and configurations – once established – tend to be inflexible, signal-processing hardware using analog parts is generally restricted to performing a narrow, dedicated task.

In response to the limitations of analog-based processing, the digital processing of signals has emerged as an alternative. The next section demonstrates how signal-processing tasks – including filtering, spectral analysis, and a host of others – can be carried out with digital arithmetic operating on digitised data.

Recent advances in VLSI (very large-scale intergration) now make is feasible to perform real-time digital signal processing with just a handful of ICs. The advantages conferred upon a system by such DSP hardware are dramatic – substantially improved performance, stability, and flexibility. Just as digital computers supplanted analog computers two decades ago in general-purpose computing applications, DSP is strongly challenging analog circuit configurations in real-time processing.

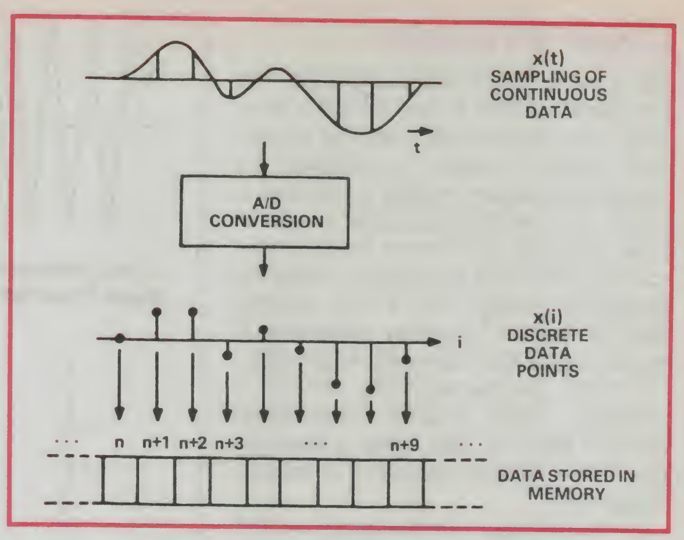


Fig.2: In DSP, continuous data is replaced by sampled data and continuous time by discrete time.

Our discussion of spectral analysis and digital filtering will benefit from a brief discussion of DSP nomenclature (there is also a brief glossary at the end of this article). Following Fig.2, an incoming analog signal is digitised, with the sampled data output points denoted x(i). The index, i, corresponds to the discrete sampling time. This sampled data is stored in a buffer and operated on by DSP hardware. The DSP algorithm determines the sequence in which data and coefficients are accessed and how they are processed. In the cases below, the computational outputs are spectral weights or filtered sampled data.

Spectral analysis

Digital spectral analysis essentially derives from the principle of *Fourier transformation*. Without going into the mathematics here, this is a mathematical technique of taking a signal's time-domain representation and resolving it into its equivalent frequency-domain spectral weights - called Fourier coefficients.

Since the basic Fourier equations linking the time and frequency domains require continuous signals, they have only indirect bearing on digital processing. However under certain circumstances, a sampled (digitised) signal can be related faithfully to its Fourier coefficients through the so-called *discrete Fourier transform* (DFT).

Again we needn't go into the maths,

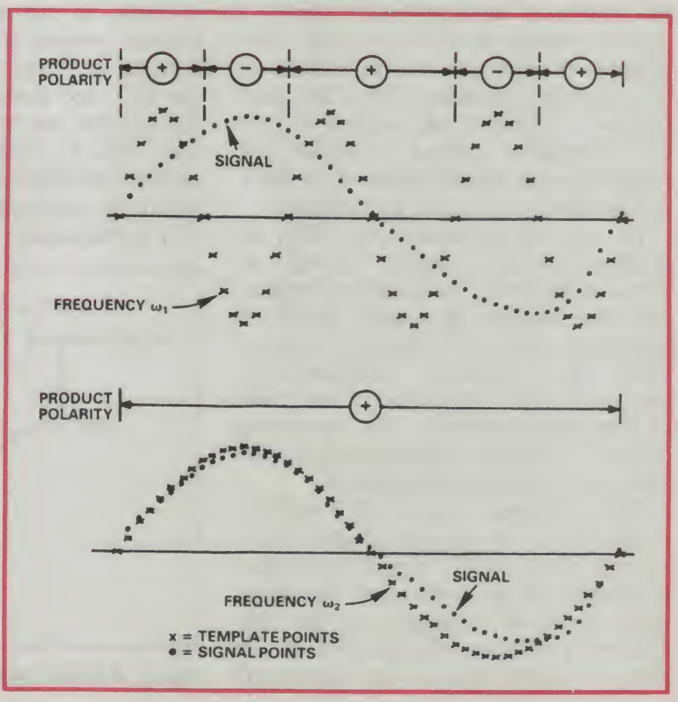


Fig.3: Comparing a signal with a sinusoidal 'template', to measure its frequency content. When the template signal is at nearly the same frequency, the polarity of the product is continuously positive.

but what is most interesting from the standpoint of DSP is that the DFT technique provides us with a means to estimate spectral content by digitising an incoming signal and simply performing a series of multiply/accumulate operations. And this gives us an accurate picture provided that the signal is sampled frequently enough (at a rate greater than its highest frequency component), and assuming that the signal is periodic.

To see qualitatively why the DFT technique yields spectral information, consider Fig.3. A time signal is superimposed on a spectral 'template' at various frequencies.

In the first case, for frequency ω_1, the input signal and the spectral template have little relationship; as a result, the positive products are more or less cancelled out by negative products. The net effect is that the summation of the product between the two in the DFT process indicates little spectral energy of frequency ω_1 in the input signal.

In the second case, however, a reinforcing pattern emerges; the signal and the template tend to be positive or negative concurrently – producing a positive product nearly everywhere. Thus, the sum of the products will be a large positive number, indicating that the incoming signal has significant energy of frequency, ω_2.

Unfortunately, the large number of multiplications required by the DFT process limits its use in real-time signal processing. The computational complexity of the DFT grows with the square of the number of input points; to resolve a signal of length N into N spectral components N^2 complex multiplications or $4N^2$ real multiplications. Given the large number of input points needed to provide acceptable spectral resolution, the computational requirements of the DFT are prohibitive for most applications.

The *fast Fourier-transform* (FFT) algorithm produces results identical to those of the DFT, but reduces computation requirements by several orders of magnitude. The FFT achieves its economies by exploiting computational symmetries and redundancies that exist in computing the DFT. The availability of the FFT makes spectral analysis feasible, at virtually real-time rates.

Fig.4 illustrates how an FFT resolves a signal into its spectral components – and the effect of FFT length on spectral resolution. In all three cases, the same input signal is examined. In the first case, we perform a 64-point FFT on the first 64 sample points; the second and third cases perform 256 and 1024-pointFFTs on the first 256 (1024) data points. The differences observed in spectral resolution underscore a key principle – the longer the time period in which a signal is observed, the sharper the spectral resolution that can be attained.

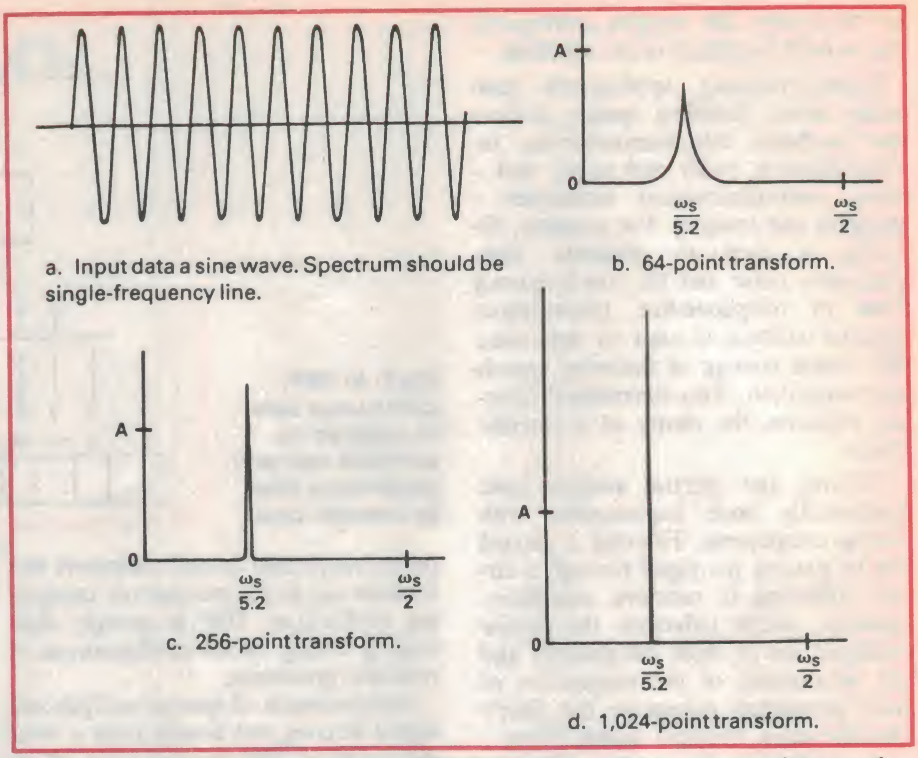


Fig.4: Fourier transform – the effect of the number of sampling points on the computed spectrum.

Bringing digital hardware to bear on a spectral-analysis task has numerous advantages. With a long-enough window of data, it can provide very precise spectral resolution. Moreover, the system can be flexibly programmed to vary the FFT size dynamically, according to the spectral resolution needed. Finally, once data is digitised, it is possible to perform additional DSP tasks, such as spectrum averaging, to further improve FFT performance.

Digital filtering

Digital filters have performance attributes similar to those of analog filters – ripple in the passband and attenuation in the stopband. What distinguishes digital filters is their ability to provide arbitrarily high performance. For example, the rolloff slope (i.e., the rate at which the filter makes a transition from the passband to the stopband) can be made virtually as steep as is desired. In general, it is straightforward to design a digital filter that easily out-performs the most complicated analog designs.

Without going into the maths involved, digital filtering essentially involves *convolving*, or adding together on a continuous basis, the products of various signal samples (representing the signal at different points in time), and

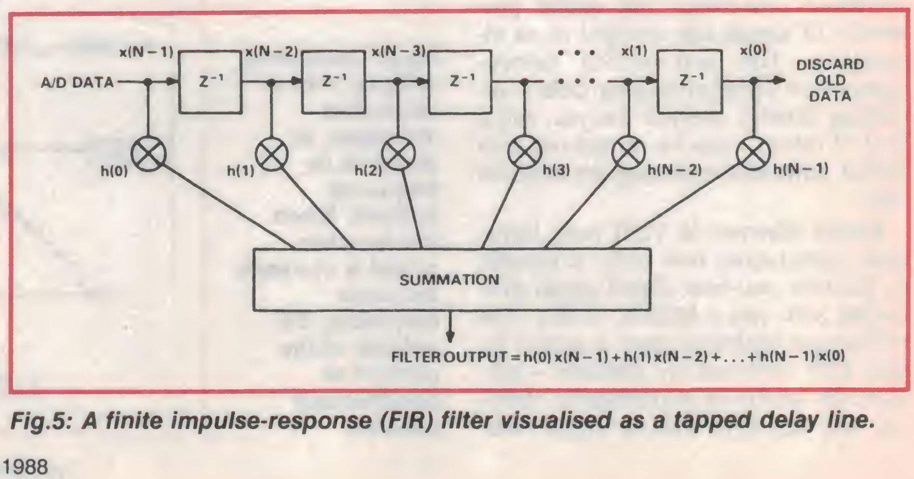


Fig.5: A finite impulse-response (FIR) filter visualised as a tapped delay line.

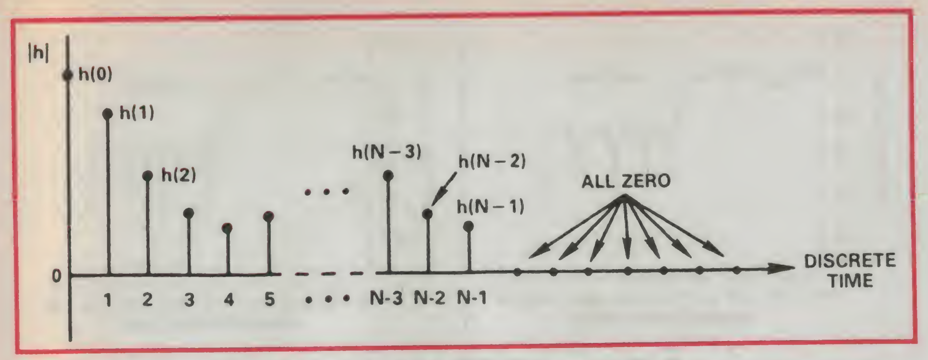


Fig.6: The impulse response h(i) of an FIR filter as in Fig.5.

suitably selected weighting factors.

In the case of a *Finite Impulse Response* or 'FIR' filter, these signal samples are all taken from *before* the filter itself. In contrast, for an *Infinite Impulse Response* or 'IIR' filter, additional samples are taken from the *output* of the filter - so-called 'feedback' terms.

FIR filters

An FIR filter can be viewed as a tapped delay line (see Fig.5); the parameter, N, corresponds to the number of taps of the FIR filter. The number of taps tells us the number of multiply/accumulate operations required to compute this convolution.

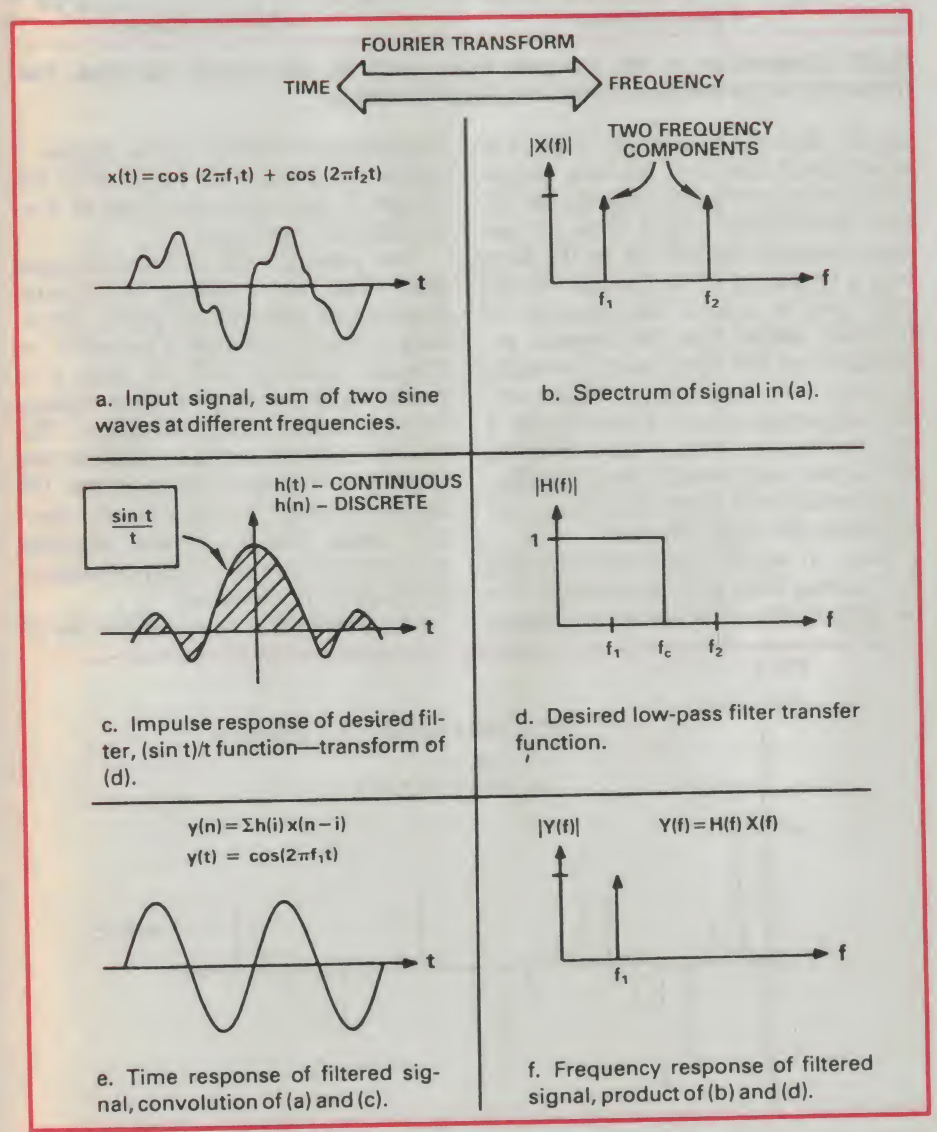


Fig.7: The basics of low-pass filter design using the Discrete Fourier Transform (DFT). The time domain is at left, frequency at right.

The coefficients, h(i), represent the impulse response of the FIR filter. As Fig.6 demonstrates, an input of 1 at time 0 ($x(0) = 1$), and zero at all other times, results in output values equal to h(i) for the periods i = 0,...,#N – 1. Note that the h(i) can be non-zero for only a finite number of time periods, hence the term 'finite' impulse response.

Since they use no feedback, FIR filters are unconditionally stable.

FIR filters can best be understood in the context of two fundamental relationships. First, a filter's time-domain impulse response, h(i), and its frequency response, H(f), are related via the Fourier transform. Second (a key principle of DSP), multiplication in one domain is equivalent to convolution in the conjugate domain.

With respect to FIR filters, this tells us that multiplying the input spectrum by the desired filter transfer function is equivalent to convolving the input time-function with the filter's impulse response in the time domain.

To further amplify the above point, consider Fig.7, where (a) illustrates an incoming signal that we wish to low-pass filter. It consists of the sum of two signals at frequencies, f_1 and f_2. Since there are just two frequencies present, its spectrum looks like (b). We'd like to design an FIR filter to filter out f_2, leaving just f_1, as shown vs. time in (e) and frequency in (f).

An ideal low-pass filter is suggested in (d); note that multiplying it by the input spectrum in (b) will give the spectral domain representation of a low-pass filtered output, allowing f_1 to pass and completely attenuating f_2. Now, the Fourier transform of (d)'s ideal filter is the *sinc* function (sin x/x) in (c). Consequently, if the input (a) is convolved with a discretised sinc function, (c), we can directly compute the filtered ouput signal, as a function of time (e).

More generally, an FIR filter boils down to simply convolving the digitised input signal with the filter's time-domain coefficients, h (i) – an action equivalent to multiplying the frequency representation of the input signal by the filter's transfer function.

Unfortunately, from the perspective of practical implementation, Fig.7(c)'s sinc function is infinite in duration. To obtain a filter that can be implemented, we must somehow truncate the number of coefficients used to represent (c); this can be carried out by discarding the tails – or, more effectively – by multiplying the function by some window. This truncation/windowing, however,

makes it impossible to realize (d)'s ideal low-pass filter transfer function, and ripple and rolloff are necessarily introduced (see Fig.9).

By taking an adequate number of taps and properly choosing the coefficients, an FIR filter can provide excellent discrimination, as the response spectra shown in Fig.8 illustrate, for various numbers of taps. In general, the greater the number of taps used in an FIR filter, the better the filter's performance, at the expense of reduced throughput.

In designing FIR filters, tradeoffs must be made among several attributes (i.e., ripple in the passband, ripple in the stopband, width of the transition band, phase distortion, and throughput). These tradeoffs are reflected in the number of coefficients used – and their particular values. This selection can be made directly in the time domain (for example, to implement a pure time delay or an N-point running average), but more commonly is made employing powerful and easy-to-use computer-aided-design (CAD) techniques to determine optimal parameter values for the desired filter performance.

The highest-performance filters of Fig.8 could not be matched by an analog-based implementation. Moreover, these digital filters are straightforward to design and implement in hardware.

There are other advantages of digital FIR filters that further increase their desirability. Once designed, they are stable; performance is insensitive to the effects of temperature or aging. In addition, a key consideration is that the filter's performance can be changed simply, just by modifying the number of coefficients used and their values. For instance, a simple software modification would shift a filter's performance from (a)'s to (d)'s – with no change in hardware, except that slightly more memory is used.

IIR filters

Infinite Impulse-Response filters are the other commonly used digital filter, differing from FIR filters in one fundamental respect: feedback. Because of feedback, the filter's impulse response can continue long after the initial impulse – indeed, for an infinite duration.

The use of feedback allows an IIR filter to economize in the number of multiplications required to provide a given filter performance. But this efficiency is not without its costs. As in other recursive systems, input perturbations can 'ring' indefinitely – in some cases causing the filter to be unstable. Also, the accumulated effects of fed-back round-off noise can noticeably degrade the filter's performance. Fig.9 plots an impulse response function for an IIR filter with a typical set of coefficients. In this case, and in general, the presence of feedback means that the impulse response of an IIR filter never converges to zero – may even diverge – hence *infinite* impulse-response. However, as a practical matter, noise, round-off error, and limited resolution do result in effective convergence when simulating analog filters that settle physically.

Even a simple single-time-constant R-C analog filter will theoretically take an infinite time to reach its asymptotic steady-state condition, but in practice it settles, for example, to 1 LSB of 32 bits within 23 time constants – and so does its IIR-filter equivalent.

Two principal IIR design techniques exist. The first considers the transfer functions of conventional analog filters, such as the Butterworth, Chebyshev, or Elliptic; a digital filter is then contructed that provides the same impulse response as its analog counterpart. The second relies on computer-aided-design techniques to arrive at an optimal IIR implementation. In this context, 'optimal' means that the number of terms needed to meet a specified performance specification is minimised.

An example that demonstrates the ef-

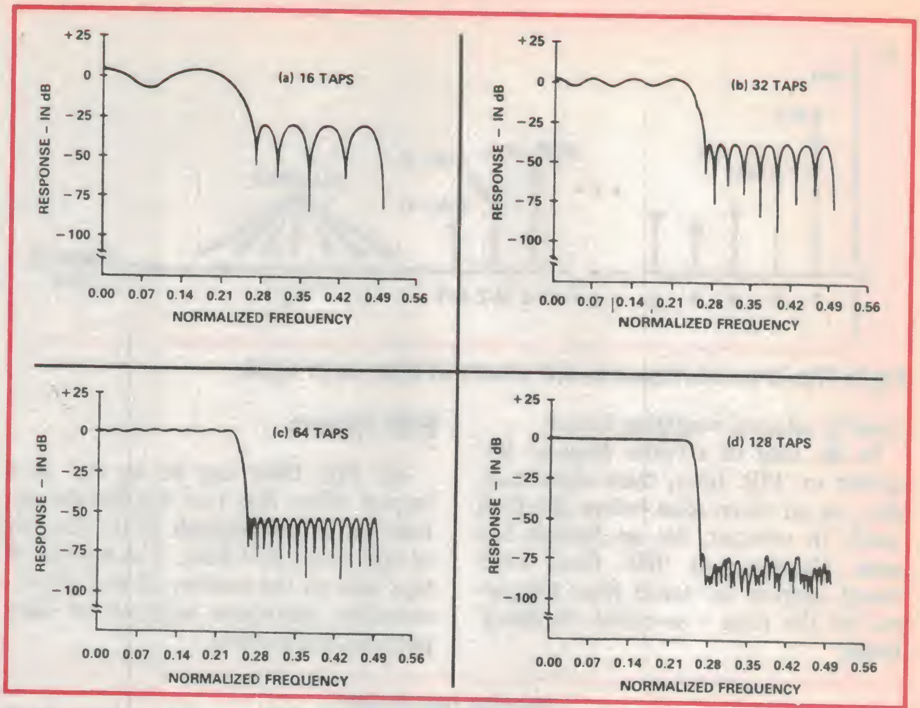


Fig.8: Comparison of FIR low-pass filters with 16, 32, 64 and 128 taps. The frequency is normalised to the sampling frequency.

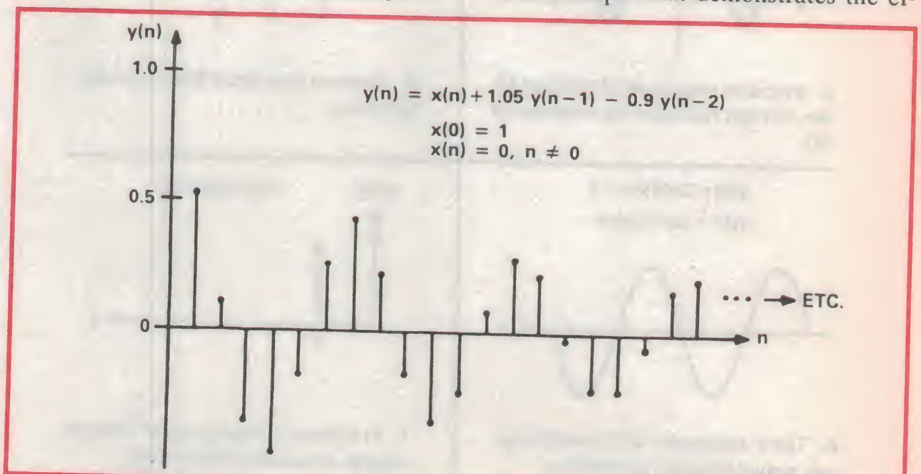


Fig.9: A portion of the impulse response of an infinite impulse-response (IIR) filter.

ficiency of an IIR implementation is a comparison of an FIR and IIR implementation of a 70dB stopband attenuation filter. To achieve this performance, an FIR filter would require nearly three times as many multiplications-per-second as an IIR implementation. These performance advantages, however, require tradeoffs to be made in other key respects, as summarised in Table 1.

Other algorithms

DSP is not limited to FFTs and digital filters. In fact, one of the prime advantages of DSP is that, once the data is digitised, fast digital hardware can perform a broad range of tasks.

Commonly used DSP routines include modulation/demodulation (heterodyning), waveform generation, correlation, estimation, control, power spectrum calculations, and multi-dimensional transforms.

While a discussion of these areas would take us far afield of this article's focus, their breadth points to an important advantage of DSP – system flexibility. By converting signals early and incorporating fast multiply/accumulate hardware to perform digital filtering and/or spectral analysis, a system can readily offer numerous enhancements.

DSP applications

DSP began as a specialised technology used in military applications. With US government funding, a high-speed integrated-circuit array multiplier was developed and first offered commercially in 1976. This multiplier formed the heart of high-performance radar, sonar, and missile-control systems.

Over time, however, the use of DSP has spread from specialised military niches into a broader set of industrial and commercial markets, as Table 2 confirms. Two important uses – modems and studio recording – are discussed below, primarily to illustrate how DSP's advantages benefit the application.

A tremendous amount of information is transmitted today over analog communication links, such as telephone lines. With the growing role of computer-based systems, this information is increasingly digital in nature (for example, digital data and digitised voice transmission). The challenge of transmitting digital data over analog links at high speeds, and reconstructing the received data with high noise immunity, thereby reducing communication costs, is met by a modulator-demodulator (modem).

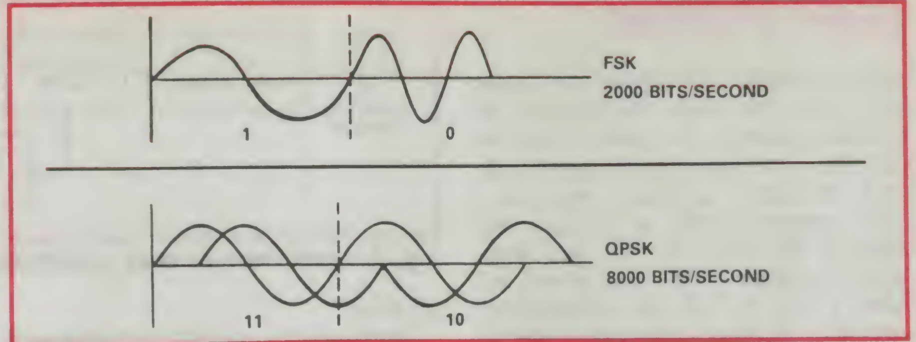


Fig.10: Frequency-shift keying (FSK) and quadrature phase-shift keying (QPSK).

In transmitting digital data over analog communication lines, a digital bit pattern is represented by modulating the phase, frequency, and/or amplitude of an analog signal. Fig.10 shows a simple scheme, which involves changing the frequency of the signal to denote a '0' or '1'; this frequency-shift keying (FSK) method can send 2000 bits/second over a telephone line.

A more sophisticated encoding method, quadrature phase-shift keying (QPSK), modifies the phase of the signal and is capable of transmitting data at four times the rate of simpler methods.

When a modem is sending information, it encodes the digital data into the corresponding analog waveform; in receiving mode, it decodes the waveform and determines the bit pattern that was transmitted. This latter mode is the more difficult to implement.

If the transmission medium were noiseless, a modem's tasks would be limited to simple encoding and decoding – a relatively straightforward exercise. However, a phone line is a noisy trans-

	IIR	FIR
Performance/Throughput	Higher	
Ease of Design		Easier
Filter Stability	Sensitive	Unconditional
Round-off Noise	Sensitive	Insensitive

TABLE 1: Comparing FIR and IIR filter characteristics.

PRINCIPAL DSP MARKETS	
Instrumentation:	Spectrum analyzers, vibration analyzers, mass spectroscopy, chromatography
Audio:	Studio recording, music synthesis, speech recognition
Communications:	Modems, transmultiplexers, vocoders, satellite transmission, repeaters, voice storage and forwarding systems
Computers & Computer Peripherals:	Arithmetic acceleration, servo controls for disk head positioning, array processors, engineering workstations
Imaging:	Medical, satellite, seismic, bandwidth compression, digital television, machine vision
Graphics:	CAD/CAM, computer animation and special effects, solids modelling, video games, flight simulators
Defense Electronics:	Radar, sonar, missile/torpedo control, secure communications
Control:	Robotics, servo links, skid-eliminator adaptive control, engine control.

TABLE 2: Applications developed to date for DSP.

mission medium, corrupting the analog waveform. The more sophisticated the encoding scheme, the more disastrous the effects of noise and channel distortion. Therefore, a modem must effectively compensate for, or equalise, this channel distortion. To this end, high-speed modems (4800 bits/second and above) turn to DSP for high-performance data recovery, using digital FIR filters.

An additional complexity of telephone-line transmission is that its distortion properties change over time. Therefore, a modem's digital filter must be able to adapt to changes in the environment. This need to respond to a changing environment underscores another advantage of DSP – a digital filter's characteristics can be modified simply by changing its coefficients. Coefficient updating in a modem is determined by the observed drift of a property of the distortion in the system.

Aided by DSP. then, a modem can make it possible for high-speed data transmission to be implemented effectively. As Fig.11 illustrates, the DSP is the heart of a high-speed modem. The processing required generally can be handled by one digital multiplier, surrounded by the appropriate support devices (a program sequencer, an address generator). Alternatively, depending on the requirements of the modem, a single-chip processor may adequately handle all DSP requirements.

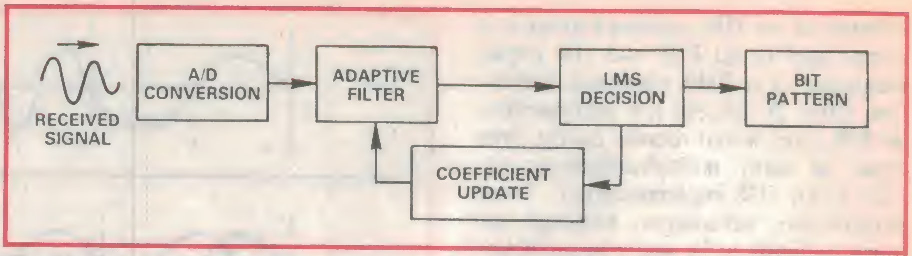


Fig.11: Least-mean-squares modem processing architecture.

Studio recording

One of the most interesting applications of DSP is emerging in the audio processing performed in recording studios. This processing starts after the initial recording of voices and instruments in the studio; after a large number of steps, it ends with the recorded version that reaches the home stereo. Increasingly, DSP is being used to handle all intermediate steps.

The flow of activities in studio recording is complex and varied. Generally, multiple channels are used, with each track dedicated to one or more sources (instruments/voices). All channels need not be recorded at the same time. Each channel is subjected to extensive processing, including gain control, filtering, non-linear compression or expansion, reverberation adjustments, spectral equalisation, and special-effects enhancements. The contributing channels are then mixed together to obtain a final arrangement with the desired overall effect.

Traditionally, channel processing and mixing were implemented entirely in the analog realm – with numerous disadvantages. Each channel's information – stored as an analog signal on magnetic tape – degrades as the cutting, splicing, and re-recording process progresses, undermining the benefits of the processing. The limited performance range available with analog processing sets a ceiling on the signal enhancement that can be attained. Also, analog circuitry can only handle one channel at a time; multi-channel mixers are expensive and difficult to control. Finally, if analog processing hardware is used, overall mixing flexibility can be achieved only through hardware modifications. In practice, this means that the mixing process loses its ability to creatively explore special effects.

Increasingly, audio processing is relying on digital techniques to improve audio quality. The first step in this transition was digital recording, which became prevalent about seven years ago. Audio signals are first converted to digital form before being stored on magnetic tape. Digital recording eliminates several sources of degradation that hamper analog recordings, including the effects of non-linearities and additive noise in the magnetic materials used for recording, and wow and flutter in the tape playback mechanism.

In studio mixing applications, however, digital recording does not eliminate all complications. In the mixing and enhancement process, information is passed from one tape to another – requiring D/A and A/D conversion processes, a source of noise. These conversions are no longer necessary if all processing and mixing are handled with DSP techniques.

In DSP-based studio recording systems (see Fig.12), signals are converted to digital as early as possible. In fact, some implementations place a remotely controlled amplifier/converter at the recording microphone. After conversion, the audio processing is handled digitally, with high performance and flexibility. Gain factors are handled with digital multiplication. Filtering and equalisation can be handled with an IIR filter that replicates the performance of standard analog filters. Alternatively, digital FIR filters can provide high-performance linear-phase filters or complex comb filters. Dynamic-range control is easily included in the system by using a multiplier for non-linear compression-/expansion computations.

The traditional mixing process is also easily implemented in a DSP-based system. Digital channels to be mixed are simply added together. Relative time delay lags can be easily introduced into the channel flows, allowing phase coherence to be explored without adding ex-

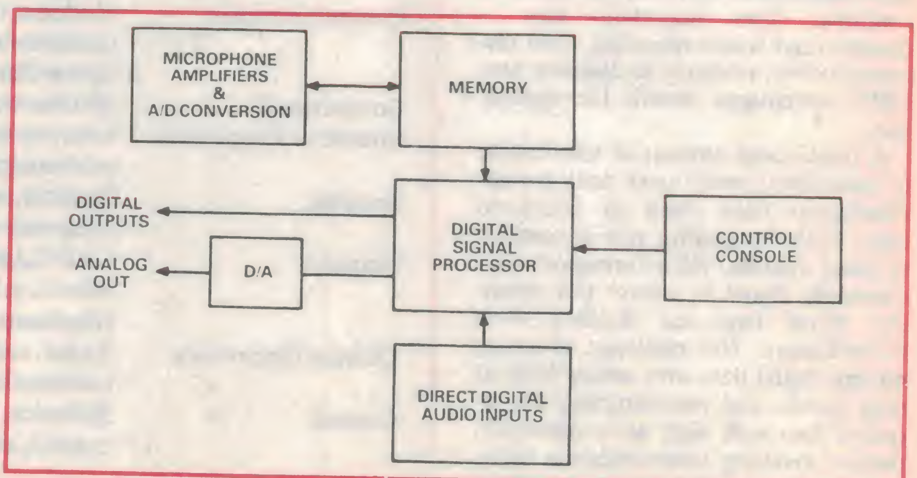


Fig.12: Block diagram of DSP applied to studio recording.

pensive delay lines to the system. An additional advantage is that the channel interconnections – which have to be hardwired in an analog processor – can be easily reconfigured in a DSP system.

In addition to improving on traditional operations, a DSP studio recording system opens up numerous new options. Unusual special effects are readily included in the system. Reverberation effects can be modelled, simulated, and integrated into the final recording. An FFT routine's spectral analysis of the signal forms the basis for frequency-domain filters that provide optimal equalisation. Overall system flexibility allows the entire mixing system to be dynamically configured – processing steps can be re-ordered, mix groups and subgroups re-specified, and effects such as fading, equalisation, and compression/expansion included at any juncture.

Studio recording, then, follows the pattern of other applications using DSP. DSP techniques offer increased precision for processing steps traditionally performed with analog circuits. Of equal importance, DSP's flexibility paves the way for many new and creative processing steps. As in other areas, the DSP is shifting the role of converters; accurate ADCs and DACs are used in the system, but as close to the real-world interface as possible. The signal processing is conducted in the digital realm.

(Adapted from 'Analog-Digital Conversion Handbook', by permission of Analog Devices, Inc.).

Glossary of DSP terms

Accumulator An arithmetic element that adds together, or accumulates, a sequence of inputs. A DSP multiplier with an accumulator on-ship is called a multiplier/accumulator (MAC).

Algorithm A DSP algorithm, such as the fast Fourier transform, or a finite impulse-response filter, is a structured set of instructions, and/or operations, tailored to accomplish a signal-processing task. Each algorithm has a well-defined structure; however, variations in algorithm parameters, such as the number of input points or taps, allow the same basic algorithm to perform different functions.

ALU An arithmetic and logic unit, which performs additions, subtractions, or logical operations (e.g., AND, OR, XOR) on operand pairs.

Attenuation The damping-out, or suppression, of signal content. Filters will attenuate the frequency content of a signal that lies in the filter's stopband.

Barrel Shifter A device that accepts a digital number as its input and – as a function of the controls – shifts the number up or down, or rotates the word as though it were placed on a barrel. A barrel shifter is used in a system for many tasks, including scaling and normalisation.

Biquad A particularly simple recursive, or infinite impulse-response (IIR), digital filter form, often used as a building block for constructing more complicated recursive filters. A biquadratic, or biquad, section uses the three most recent input points and the two most recent output, or feedback, values to compute each output point.

Block Floating Point A compromise between fixed-point and floating-point arithmetic. Data grouped in "blocks" is assumed to be normalised with a common exponent (but, not being attached to the data words, the exponent need not be explicitly processed with the data). In essence, the process is carried out in fixed point, with its inherent speed advantage.

Convolution In discrete computations, a mathematical operation, defined as the summation, or integral, of a product of two functions over a range of differences in the independent variable. In the time domain, one function is the impulse response, as a set of coefficients, h(i), over N time intervals; the other is the input, f(n – i), as a function of the differences between the time at the instant at which the function is being evaluated, n, and the input at earlier instants, determined by the variable delay, i, from 0 to N. In DSP, the convolution of an input signal, x, with the coefficients, h, results in the filtering of the input signal.

Correlation A mathematical operation that indicates the degree to which two signals overlap. A high positive correlation reflects two signals that closely track each other. A negative correlation indicates that the two signals are closely related, but out of phase by roughly 180°. If the correlation is close to zero, the two signals are unrelated.

Digital Signal Processing DSP is a technology for high-performance signal processing that combines algorithms and fast number-crunching digital hardware.

Discrete Fourier Transform The discrete Fourier transform (DFT) is a DSP algorithm used to determine the Fourier coefficient corresponding to a particular frequency.

FFT An n-point fast Fourier transform (FFT) is computationally equivalent to performing n DFT's but, by taking advantage of computational symmetries and redundancies, can reduce the computational burden by several orders of magnitude.

FIR Filter A finite impulse-response (FIR) filter is a commonly used type of digital filter. Digitised samples of the signal serve as inputs; each filtered output is computed from a weighted average of a finite number of previous inputs.

Fixed-Point Arithmetic Each number is represented in a fixed arithmetic field of n bits, allowing integers in the range 0 to $2^n - 1$, to be represented.

Floating-Point Arithmetic Each number consists of a mantissa and an exponent, allowing wide dynamic range to be accommodated in the numbering system.

IIR Filter An infinite impulse-response (IIR) filter is a commonly used type of digital filter. This recursive structure accepts as inputs digitised samples of the signal; each output point is computed on the basis of a weighted average of past output – or feedback – terms as well as past input values. An IIR filter is more efficient than its FIR counterpart, but poses more challenging design issues.

MAC Multiplier/accumulator; see Accumulator.

Microcode A set of instruction control signals in a program memory that govern the cycle-by-cycle operation of the various devices in a building-block architecture.

Passband The frequency range over which a filter passes, to within some tolerance, the incoming signal content.

Pipeline An architectural structure that allows two or more operations to be carried out simultaneously, like the stages of an assembly line. While each basic operation requires several cycles to complete, a later stage of one operation is simultaneous with an earlier stage of another operation. This structure allows the effective throughput rate for each operation to be substantially increased.

Rolloff A measure of filter performance defined as the rate-of-change of the filter's amplitude response with respect to frequency over a transition band.

Stopband The frequency range over which a filter attenuates, to within some tolerance, the incoming signal content.

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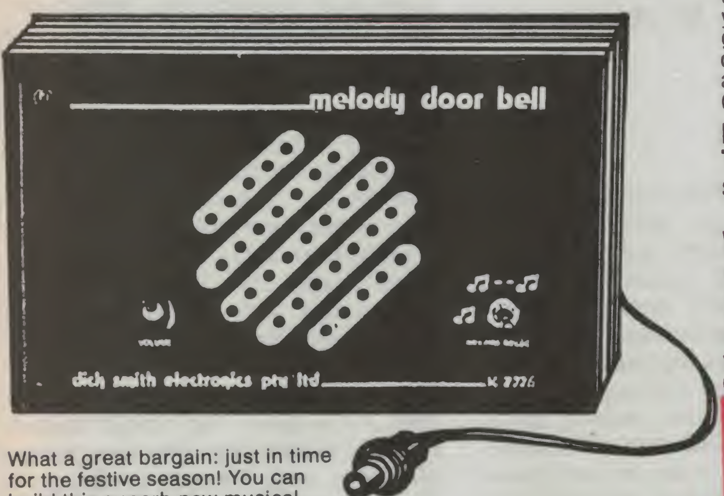
Build yourself a door-bell and we'll throw in an extra 8 Xmas tunes: FREE!



What a great bargain: just in time for the festive season! You can build this superb new musical doorbell , with 16 popular evergreen tunes, and we'll also include FREE a second tune chip with 8 extra Christmas tunes and Carols! What a fantastic project to build -and now you'll really impress the friends and rels this Christmas!

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What break, you say! OK - why not take advantage of the couple of days off to build yourself a great kit. Like these superb hi fi speakers, for instance:

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Put them together in a night or so - and you'll have a great pair of speakers rated at approx. 40 watts cont (100W max). All you need is some glue, a screwdriver and a bit of time. Attractive woodgrain type finish.

You'll need:

An enclosure pack (K-4000) $212^50

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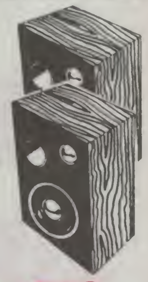

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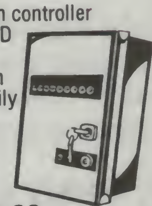
Build your own alarm controller and really save - AND only you will know the particular system you've built. It's easily good as most commercial alarms, too! Cat K-3424



Normally $149.00
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Nifty little idea for security alarms, etc. Photosensitive IC senses changes in light level when someone walks in front of it. Neat - but effective! Cat K-2721

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Why build yourself an AM radio when you can buy one - possibly even cheaper. Just for the fun of it! PS - Betcha this beats the pants off one you'd buy! Cat K-2720

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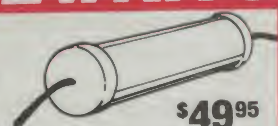
NEWKITSNEWKITS

Masthead Amplifier

Crook TV signal? Build your own masthead amplifier and fix it! Very simple to build, comes complete with all hardware, power supply, etc. Easy one night project. Cat K-5800



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Multi-Purpose Pre-Amp

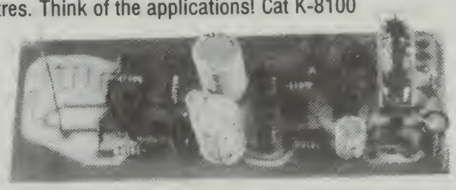
Here's versatility! EA's ingenious new pcb is adaptable to just about any preamp - or the power supply for same. Whatever you want in audio preamps - you've got! Short form kit - includes pcb, op-amp etc; you supply passive components depending on type of preamp you want. Cat K-5010

$9^95

Proximity/Motion Detector

Another new one from AEM. It's an oscillator which reacts to bodies (yours, anyones!) -up to 20 metres away. Adjustable sensitivity down to centimetres. Think of the applications! Cat K-8100

$36^95



Remote Switch Transmitter

A really worthwhile add-on to for car alarms, etc etc. Suits the devices recently described in Silicon Chip - this kit is for the transmitter only. (EG a spare, one for your partner, etc etc). Cat K-8150

$16^95

New single-chip DSP micro eases system design

A new pair of lower-cost single-chip DSP microcomputer chips from Analog Devices combine Harvard architecture with on-chip memory and dual serial interfaces, to provide cost effective solutions for signal processing.

by GREG KOKER
Analog Devices DSP Division

The ADSP-2101 and ADSP-2102 are two new high performance microcomputers designed for digital signal processing applications. Based on Analog Devices' ADSP-2100 architecture, they provide a more cost effective solution for applications where the ADSP-2100 is too expensive.

The ADSP-2101/02 contain many new features, including on-chip memory, serial ports with autobuffering capability and programmable wait-state generation.

Present users of ADSP-2100's don't even have to change their software; the ADSP-2101/2 are object code compatible. On-chip "boot" loading hardware allows the internal memory to be simply loaded from a single 27xxx series EPROM.

The ADSP-2101 contains 64K bits of static RAM, configured as 1K x 16 data RAM and 2K x 24 program RAM. The program RAM can be used for both instructions and data. The ADSP-2102 is a mask ROM version of the ADSP-2101, with the 2K x 24 program RAM partially replaced by ROM.

Since the ADSP-2101/02 has the same architecture as the ADSP-2100, they make up a family of object code compatible processors. The devices all share the same computation units and assembly code syntax. Programs designed to run on the ADSP-2100 will also run on the new processors.

Fig 1 shows the internal architecture of the ADSP-2101/02, with the new features added to the ADSP-2100 block diagram. The control registers for the new portions exist as previously unused register codes and memory mapped registers. The microcomputer executes most instructions in one processor cycle.

All three Analog Devices DSP components have separate memory spaces for the program and data. This allows for simultaneous access of instructions and data. This is usually refered to as a Harvard Architecture. The ADSP-2100 has separate address and data busses for each of these spaces. Instructions can also be fetched from the on-chip 16 word instruction from the cache, it can also read data from the program memory. This permits two operands and one instruction fetches per processor cycle.

The ADSP-2101/02 has separate internal address and data buses for each of the two memory spaces. The internal data and program RAM are sufficiently fast to allow both an instruction and a data fetch to occur each cycle. The ADSP-2101/02 can also do one external fetch (from either data or program memory spaces) per cycle as well. The processor will execute all instructions in one cycle, provided that no more than one external fetch is necessary.

The on-chip memory on the ADSP-2101 is organized as 1K x 16 data RAM and 2K x 24 dual purpose program RAM. The data RAM is located in the first 1K locations of the 16K word data RAM space. It is used whenever the program references an address between 0 and 1023. Any other data memory address causes an external memory cycle to occur. There is no penalty associated with accessing external memory if appropriately fast memory is used, and if only one external access is necessary to execute the current instruction. This allows the user to have large amounts of data memory and still achieve full processor performance.

The on-chip 2K x 24 program RAM can be used both for instruction and data storage. This RAM can be located in one of two address ranges, either the first or last 2K locations in the 16K program RAM space. The MMAP control pin determines which of the two configurations is used. The first configuration is useful when the internal program RAM is being used to store instructions. This allows the interrupt and restart vectors to be stored internally and removes the need for external memory.

Having the internal RAM mapped to the last locations of memory permits interrupt vectors in the external memory space. Like the data RAM, external memory cycles are generated when the referenced address is outside of the internal memory space. There is no penalty for accessing external program memory as long as only one external access is required by the current instruction and sufficiently fast memory is used.

The program space can also be used for data storage. The internal program RAM is fast enough to be accessed twice during each instruction cycle. This allows both an operand and the next instruction to be fetched during the same cycle.

The ADSP-2100 has an instruction cache to allow instructions to be read

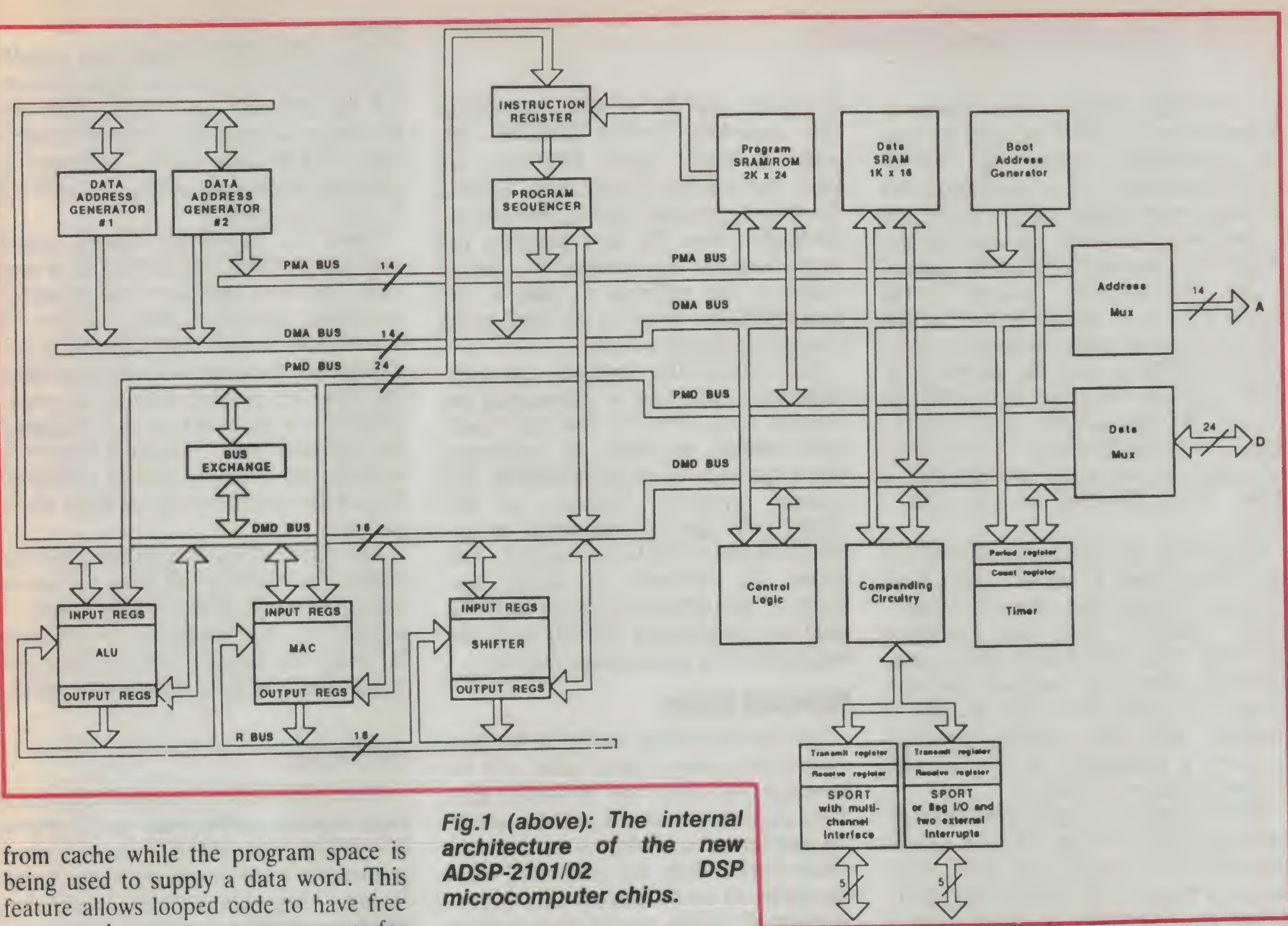


Fig.1 (above): The internal architecture of the new ADSP-2101/02 DSP microcomputer chips.

from cache while the program space is being used to supply a data word. This feature allows looped code to have free access to the program memory space for data fetches, and provides what is effectively a three bus architecture. Since the internal memory can be accessed twice per cycle on the ADSP-2101/02, the instruction cache is not necessary to obtain this 'three bus' performance.

The external program and data memory spaces feature on-chip programmable wait state generation. This feature is useful for interfacing to slow memory without any external hardware. From zero to seven wait states can be added, to accesses to either external memory space. The number of wait states added are independently programmable for each external memory space.

Boot memory

DSP microcomputers often have on-chip ROM which can be used for storing programs. This provides a single chip production solution, but makes development costly and time-consuming. Often these processors require the use of external memory during development and then switching to ROM for the production design.

Some manufacturers provide a partial solution to this problem by replacing the typical ROM with either EPROM

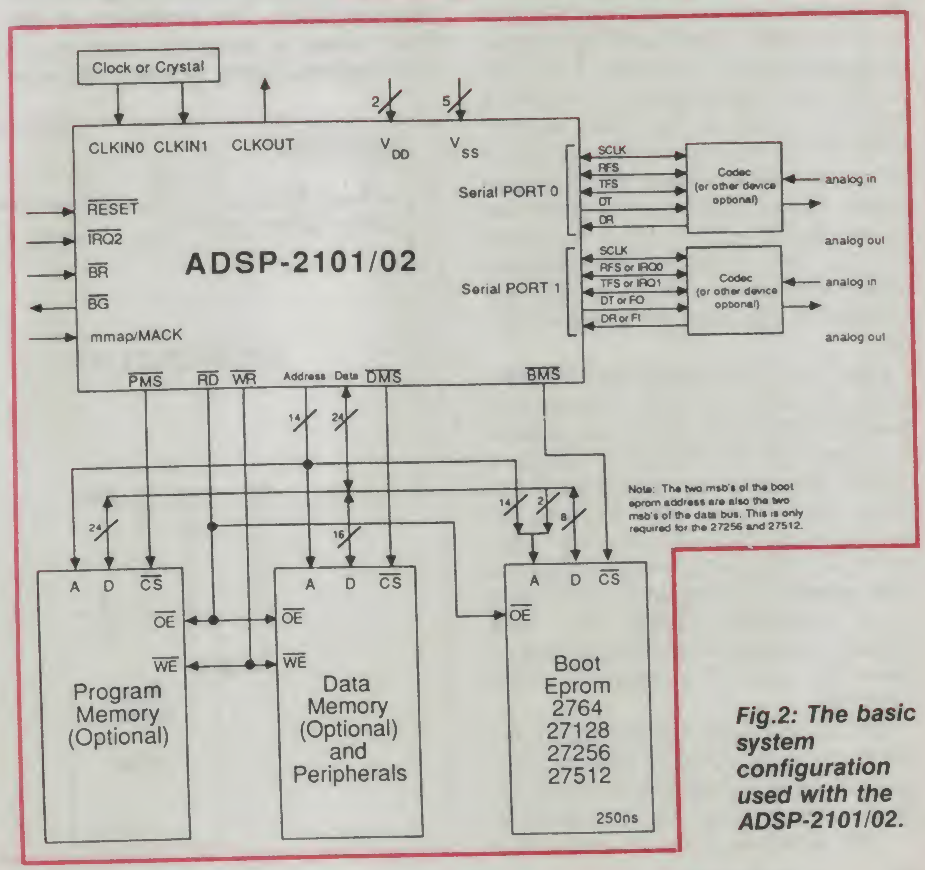


Fig.2: The basic system configuration used with the ADSP-2101/02.

or EEPROM. Unfortunately these alternatives are available on only the lowest performance parts. The ADSP-2101/02 provides a new solution to this problem by providing on-chip RAM and a convenient method for loading this RAM from an external memory space.

The boot memory circuitry of the ADSP-2101 is a unique feature which allows use of an single inexpensive byte-wide EPROM to load the internal program memory. A single 2764 EPROM can fill the internal 2K x 24 memory space of the ADSP-2101. No additional hardware is necessary to connect a 2764, 250ns EPROM to the ADSP-2101.

Fig.2 shows an example system. When the system reset is released, the boot memory circuitry loads the internal program memory from the external EPROM. The ADSP-2101 then starts operating from the internal program memory at address 0. This feature is disabled when the internal program memory is configured as the last 2K program memory addresses.

The boot memory space consists of an external 64K x 8 space, divided into 8 separate 8K x 8 'pages'. Up to 6K bytes are used to store the data for the internal program memory. A length code in the external memory provides the ability to load only a portion of the internal program memory. This feature is useful to limit the time necessary to load the memory, as well as the ability to leave some of the internal memory available for passing data between different programs. Up to 8 separate programs can be provided if a 27512 EPROM is used for the boot memory. No additional components are necessary to take advantage of this multiple program feature.

Page 0 of the external boot memory space is used to store the progam loaded initially after reset. The remaining pages can be loaded by setting a control register to the page desired. Another control bit is used to force the loading of the desired page. The number of wait states used while reading the boot memory is programmable from 0 to 7 instruction cycles. The boot memory interface is set during reset to allow the use of inexpensive 250ns EPROM.

The multiple page feature allows the ability to switch between different programs without having the need for expanding the program memory externally. The switching between these 'boot programs' can be a time consuming task, especially if slow EPROMs are used. If higher speed EPROMs are used, the number of wait states used in the loading process can be adjusted accordingly (after the first program has been loaded). By storing the actual length of the program as data in the boot EPROM, there is no time spent loading meaningless data.

The ADSP-2102 provides an additional cost reduction by eliminating the external boot EPROM. The only hardware change necessary to implement this is the removal of the EPROM. The internal program memory on the ADSP-2102 can be configured as any combination of RAM and ROM. This allows the customer to decide how much of the internal program RAM is used for instructions (ROM) and how much is left for data storage (RAM.)

Interval timer

The ADSP-2101/02 has a 16 bit programmable interval timer with an 8 bit prescaler. The timer can be used to generate periodic interrupts and to specify the resolution in multiples of the processor cycle. With the prescaler, users can trade off total delay and resolution. A delay of 5.24ms can be made with an 80ns resolution. The expiration of the timer causes a maskable interrupt to occur and the timing period starts over again.

The ADSP-2101/02 have bus request and bus grant signals, to allow tri-stating the external bus signals. Since the processor can operate completely internally, it is possible for the processor to continue operations while the external buses are granted.

There is a new mode control option called GOMODE. If GOMODE is enabled, then the processor will continue instruction execution until an external access is necessary. If GOMODE is disabled, then the processor will stop when the buses are granted whether an external access is necessary or not. Stopping the processor from operating internally is useful for reducing power consumption or for synchronising multiple processors.

The ADSP-2101/02 also have a new instruction WAIT which waits for an interrupt to occur. WHen the processor is stopped by this instruction or because the buses are granted, the processor enters a reduced power consumption state.

SPORTS

The ADSP-2101/02 contain powerful programable synchronous serial ports (SPORTS). The SPORTS have a programmable word length between 3 and 16 bits. These SPORTS are useful for simple interface to popular data conversion products such as codecs, A/D and D/A converters, as well as interprocessor communication. Each SPORT inter-

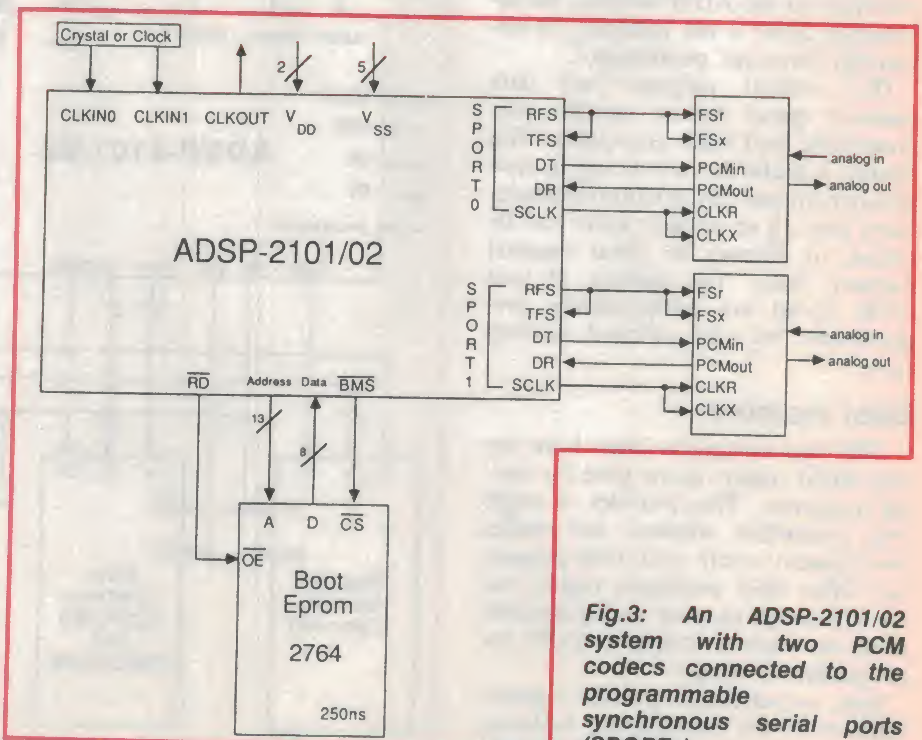


Fig.3: An ADSP-2101/02 system with two PCM codecs connected to the programmable synchronous serial ports (SPORTs).

nally generates serial clock and frame signals. Both SPORTS contain unique automatic buffering circuitry which allows SPORT data to be written and read directly from data memory.

Codecs, which are used in many telecommunications applications, use non-linear encoding algorithms to compress 13 or 14 bits of dynamic range into a coded 8 bit balue. There are two algorithms in common use, A-law and u-law.

Most DSP applications require conversion of these coded values to their linear values. The ADSP-2101/02 provides dedicated hardware to remove the overhead of these conversions. When this hardware is enabled, the transmitted and received data are converted automatically with no overhead.

Each SPORT has individual control of whether A-law, u-law, or no companding occurs. This allows one SPORT to be operating with the companding enabled for a codec, while the other operates without companding.

Fig.3 and 4 show some examples of how the ADSP-2101/02 SPORTS can interface to common codecs, serial A/D-D/A, and even another ADSP-2101/02. The SPORTS have a five pin interface which consists of a clock, two data pins, and two framing signals. The serial clock is configurable as either an input or an output. Each SPORT is capable of generating an independent clock between 93.75Hz and 6.144MHz (with a 12.288MHz instruction rate). The SPORTS can operate with an external clock between 0Hz and 12.5MHz.

Frame signals

The frame signals have many programmable features which allow for common framing protocols, internal frame generation, and even programmable inversion. There are separate frame signals for the receive and transmit sections of each SPORT.

There are two methods by which the internal frame signals can be generated. One method is based on a programmable division of the serial clock. This method is useful with continuous clocks to generate periodic transfers and operates whether the serial clock is internally generated or externally provided. The divider circuitry provides up to 65536 cycles between transfers. Fig.3 shows an example system where this type of frame generation is useful. The ADSP-2101/02 can generate all the necessary signals for two independent PCM codecs.

The other method for internal frame signal generation is based on data being available for transmission. The appropriate frame signal is generated whenever there exists a valid 'non transmitted' data word in the transmit data register. This method is useful for interprocessor communication.

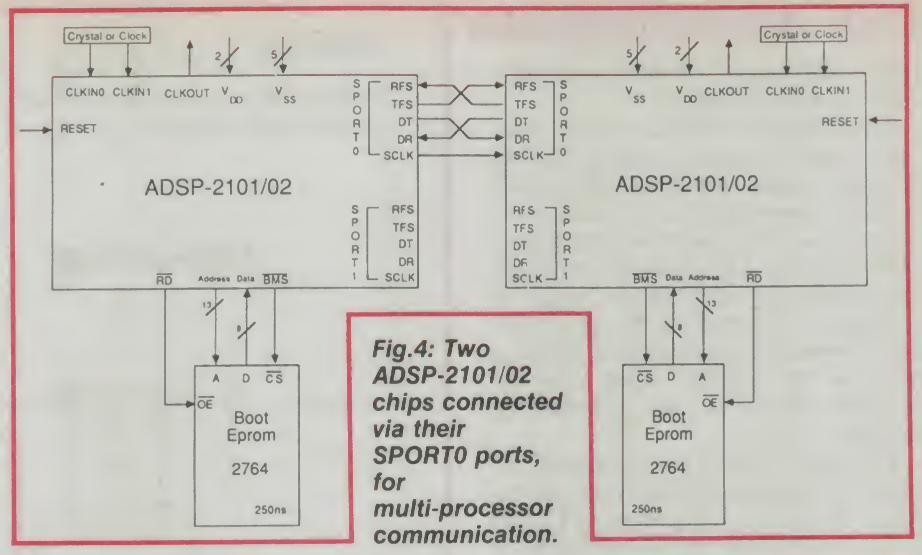


Fig.4: Two ADSP-2101/02 chips connected via their SPORT0 ports, for multi-processor communication.

Fig.4 shows two ADSP-2101/02 processors connected serially. the processor on the left generates the serial clock. Each processor generates its own transmit frame signal, which serves as the receive frame signal for the other processor. When either processor writes to its transmit register, a receive sequence occurs on the other processor. The other SPORT on each processor is available for connection to a codec or other serial peripheral.

One problem that many processors have is the overhead involved with serial port transfers. Many DSP algorithms operate on blocks of data. This requires the serial port interrupt handlers to keep track of the number of transfers, and multiple instructions to be executed for each serial port transfer. The autobuffer feature of the ADSP-2101/02 SPORTS is provided to help reduce the overhead for SPORT data transfers. This feature allows the SPORTS to read and write directly to the data memory, interrupting the processor only after a specified number of transfers occur.

DAG circuitry

The autobuffer circuitry uses the powerful *data address generator* circuitry (DAG) to generate the necessary addresses for the buffering of SPORT data. When enabled, the autobuffer circuitry uses a specified DAG register combination to provide an address for the SPORT data transfer. The autobuffer circuitry steals a single instruction cycle for its operation and does not otherwise interfere with normal processor operations.

A SPORT interrupt occurs only when the DAG has a modulus overflow as a result of updating the pointer used for the transfer. By selecting an appropriate buffer length and modification value, the user can implement many interrupt schemes. Some possibilities for automatic interrupt generation are when the buffer is full, or when the buffer is half full, or when the buffer is empty. The overhead for the SPORT transfers is only a single cycle for each transfer and then the normal interrupt overhead only when the buffer is ready to be operated upon.

Say for example that a particular application requires 128 data words to operate on. A single 256-word circular buffer could be used to allow 128 words to be read in (the next block) while the current block is being operated upon. The processor could be interrupted every 128 words to switch between the buffer halfs. Only one cycle is used per transfer of SPORT data. The interrupt routine would only be called once every 128 words, so a large percentage of the normal overhead is removed. This type of operation works equally well for the transmit and receive operations.

SPORT0 contains a special multichannel interface. This is used to provide arbitrary word selection from 24 or 32 word multiword protocols. Enabled words are transmitted and received in the normal fashion. Disabled words are ignored when received, and the transmit data pin remains tri-stated. In this mode, the receive frame sync signal operates as the frame information for the receive and transmit operations. The transmit frame sync signal becomes a

DSP microcomputer

word valid signal to indicate externally which words are selected.

An example of the use of this interface could be in secure communication. Say for example that the ADSP-2101/02 is used to encode/decode information on one or more channels in a multi-channel serial network. The channel(s) on which the coding operation occurs could be dynamically selected by the processor. Fig.5 shows a simple hardware interface to allow the uncoded words and the decoded words to be appropriately merged.

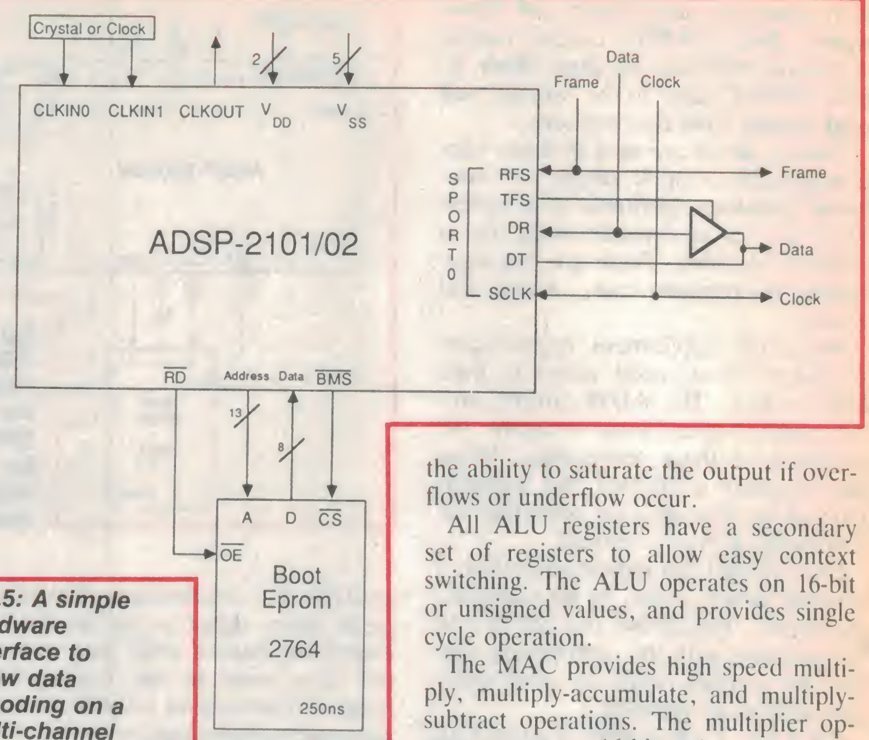


Fig.5: A simple hardware interface to allow data encoding on a multi-channel serial network.

The ADSP-2101/02 have the ability to replace the second SPORT with two external interrupts, a flag input (FI), and a flag output (FO). In this configuration the flag input can be used to control program flow from an external source. Its sampled value is available as a condition code for a conditional branch instruction. The FO can be set, reset, or toggled by a new instruction. This allows the program to simply control an external circuit. Possible uses for the input and output flags could be to start a conversion in an A/D or D/A converter, or to test if a conversion has completed. The additional external interrupts can be programmed to be either level or edge sensitive.

Maths function

The Arithmetic Logic Unit (ALU), Multiply-Accumulator (MAC), Barrel Shifter, and Data Address Generators (DAG) are common to the ADSP-2100, ADSP-2101, and ADSP-2102. The computation units all have separate input and output registers and provide single cycle operation. Multi-function instructions allow two operands to be fetched in parallel with an ALU or MAC operation. The sequencer provides zero overhead nested loops, JUMP, CALL and nested interrupt support.

The DAGs provide indirect addressing for operand fetches from the data and program memory spaces. Each of the two DAGS contain four index, modify, and length registers. The index registers are used to contain the address. The modify registers are used to modify the address in a post-modify scheme. The length registers are used as part of the modulus logic to provide circular buffer capabilities. One of the DAGs also has a bit reverse capability which is useful for FFT algorithms.

The ALU provides a standard set of arithmetic and logic functions such a add, subtract, negate, increment, decrement, absolute value, AND, OR, Exclusive OR and NOT. Two divide primitives are also provided, to simplify the division operation. Also provided is the ability to saturate the output if overflows or underflow occur.

All ALU registers have a secondary set of registers to allow easy context switching. The ALU operates on 16-bit or unsigned values, and provides single cycle operation.

The MAC provides high speed multiply, multiply-accumulate, and multiply-subtract operations. The multiplier operates on two 16-bit values and produces a 32-bit product which is added/-subtracted from a 40-bit accumulator. The 40-bit accumulator allows for a larger range of intermediate value. All MAC registers have a secondary set of registers to allow easy context switching. The MAC provides single cycle execution for all operations.

The SHIFTER allows for easy data scaling and data formatting operations. The shifter allows placement of a 16 bit value anywhere in a 32 bit output field. The SHIFTER provides the following operations: arithmetic shift, logical shift, normalization, denormalization, derive exponent, and derive block exponent. Like the ALU and MAC, there is a secondary set of registers associated with the SHIFTER to allow easy context switching.

The program sequencer provides the necessary program control features such as branching, subroutine calls, interrupt control, and looping operations. Four levels or zero-overhead looping are provided. Each level of looping can be terminated by any processor condition code, or by the expiration of a programmable down counter. Up to five nested levels of down counter can be achieved.

Further information on the ADSP 2100, 2101 and 2102 DSP microcomputers is available from the Australia distributor for Analog Devices, Parameters Pty Ltd., at 25-27 Paul Street North, North Ryde NSW 2113, or 1064 Centre Road, Oakleigh South VIC 3167. Phone (02) 888 8777 or (03) 575 0222.

Real world signal components

with down-to-earth specs.

Model	Resolution	No. Channels	Conversion Rate	Data Access Time	F.I.F.O.	Size
AD1332	12 Bit	1	125 KHz max	15 nS	32 word	x 12 Bit
AD1334	12 Bit	4	64 KHz max	15 nS	32 word	x 14 Bit
AD7878	12 Bit	1	100 KHz max	40 ns	8 word	x 12 Bit
AD7672	12 Bit	1	330 KHz max	90 ns		NIL

NOTE: We also have a complete range of A to D converters to suit all Real World conversion applications.

Model	Cycle Rate	Data Memory	Program Memory	Cycle Time
ADSP2100	6 or 8 MHz	16K x 16 Bit (External)	32K x 24 Bit (External)	170 nS (6) 125 nS (8)
ADSP2100A	10 or 12.5 MHz	16K x 16 Bit (External)	32K x 24 Bit (External)	100 nS (10) 80 nS (12.5)
ADSP2101/2	12.5 MHz	1K x 16 Bit (Internal)	2K x 16 Bit (Internal)	80 nS (12.5) 80 nS (12.5)

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Digital audio production system

An excellent illustration of the way digital signal processing is revolutionising professional audio is provided by the new 'Opus' professional audio production system developed by US company Lexicon Inc.

The Opus system is optimized for a wide range of audio production applications. For TV and film production, Opus offers sound effects editing and pre-lay; dialog recording, editing and replacement; and music editing. Other applications include CD preparation and radio production. By combining the functions of a multi-track recorder or film dubber, a digital audio editor and a digital mixer, Opus offers innovative capabilities not available in other audio processors.

The key to Opus' performance is its distributed DSP processing architecture. In a distributed system each element can be optimised for a unique task. When linked, the entire network can achieve processing throughput that would be impossible for a single processor.

For example, Opus has the unique ability to perform several signal processing tasks – such as 'scrubbing' full bandwidth audio directly from the hard disk, editing, mixing, recording and playback – concurrently in the digital domain.

Overall view of the Opus system with the digital control section at upper right.

Since Opus is a modular system, each Opus can be configured for a particular application. Purchasers can specify the number of storage disk drives and the I/O configuration. Future Opus options such as digital EQ, digital dynamics processing and mixing automation can be added as needed.

The Opus system is controlled from a sophisticated workstation that combines aspects of a multitrack recorder, an editor, a mixing console and a personal computer. It holds up to twelve channel strips, channel faders, a master/monitor strip and master fader, along with a CRT screen, an alphanumeric keyboard, soft-labeled function keys and the edit knob. Expansion slots are provided for signal processing control modules.

Each Opus channel strip includes a dual 200-segment plasma level meter, four auxillary sends, input trim, record, pan, mute and solo controls, along with a Penney & Giles 104mm fader. In addition, there are controls for unique functions such as Access Channel ID and Mode Select along with an 8-character soft label.

The Opus workstation itself handles no audio material, but sends control signals to the electronics cabinet which houses the digital processors, the analog and/or digital audio I/O interfaces, power supply, ventilation, backup sub-systems and a disk drive.

This complete isolation of the audio and control signal is all the more remarkable when the workstation is seen in operation. It controls levels for the eight disk outputs and four additional inputs in real time, and entirely in the digital domain. The engineer or editor uses familiar long-throw faders and sees the results on a plasma bar graph meter bridge.

This design allows the Opus user to take full advantage of intuitive mixing skills, developed over years of professional practice. Because it eliminates the need to access a separate 'mixing' or level control screen, digital mixing can be done at any time without interrupting work flow

For bit-accurate backup, restoration and archiving of projects produced on Opus, two options are offered: streaming tape and random access removable media. The reusable streaming tape cartridges are fast, cost-effective and convenient. They have the high-data capacity required for day to day backup operations.

Optical disks combine very high disk storage capacity with the flexibility of a removable cartridge format. They also offer long life and random access retrieval, features which make them ideal for creating and archiving sound effects libraries.

The integrated design of Opus makes conventional audio production operations easier and faster. It also gives the engineer, editor and producer the power to refine and re-shape a soundtrack in entirely new ways.

"Opus began as a comprehensive audio production system," says Joel Silverman, Lexicon's director of sales. "Instead of adding features to a muscial instrument synthesizer or grafting rudimentary editing functions onto a digital audio storage system, we built a dedicated audio production system from the ground up. As Opus makes its way into the everyday world of meeting deadlines, our approach's practicality will become increasingly clear."

For further information on Opus contact the Australian distributor for Lexicon, Amber Technology, PO Box 942, Brookvale 2100 or phone (02) 975 1211.

New Products

Wattmeter has data bus

The DW-6070 AC wattmeter is a portable, battery operated instrument with a special in-built data bus that allows readings to be printed out on-site or later transfered via a serial interface to a computer for analysis.

This remarkable capability is available through the DW-6070's in-built data bus terminal for interfacing with a computer or a small dedicated printer. The unit, however is practically the same price as AC wattmeters without a data bus.

The wattmeter measures true power (not apparent power), AC voltage and AC current. The large LCD display, built in over-input indication and battery low indication combine to make a very easy to use and practical unit.

Ranges include 2000W and 12,000W with a resolution down to 0.1V and accuracy of +/-1%, 200V and 750V with resolution down to 0.1V and accuracy of +/-0.8% and a current range of 15A with resolution of 10mA and accuracy of +/-1%.

For further information contact Emona Instruments, 86 Parramatta Rd, Camperdown 2050, phone (02) 519 3933.

Fuel cut-out solenoid

A device currently receiving a lot of attention in the automotive security industry is the fuel cut-out solenoid. This is probably because it provides a relatively simple and effective means of making sure that a thief doesn't actually get away with a vehicle being broken into. No fuel – no go.

Fuel cut-out solenoids are specialised electromechanical products which are usually made exclusively for car alarm manufacturers. However, a kit is now available to electronic hobbyists from Oatley Electronics.

The kit, priced at $57.90, includes the fuel cut-out solenoid, a large double-pole double-throw switch, two hose adaptor couplings (fuel input and output), 300mm of fuel hose, four hose clips and printed information. The information includes specifications, a wiring diagram, installation instructions and several suggested circuit diagrams. The double pole switch makes it possible to have some type of indicator such as a piezo buzzer or a lamp, to remind the owner that the fuel cut out is activated.

The fuel cut-out assembly is an Australian product and is designed to permit fuel flow when power is applied to the solenoid coil.

For more information on the described kit contact Oatley Electronics, 5 Lansdowne Pde, Oatley 2223 or phone (02) 579 4985.

IBM-PC I/O PCB

Procon Technology has released an externally mounted digital I/O board for 'real-world' computer control applications. The PC-IO-NR provides eight optically coupled inputs and eight relay outputs on a board measuring 240mm x 100mm.

The board is suitable for a multitude of applications in industry, the home or school. These boards are capable of being daisy-chained to provide a total of 120 inputs and 120 outputs using a special 8 bit bi-directional card (PC-BD-IO), also available from Procon Technology.

Each PC-IO-NR board comes complete with demonstration software and full instructions for use.

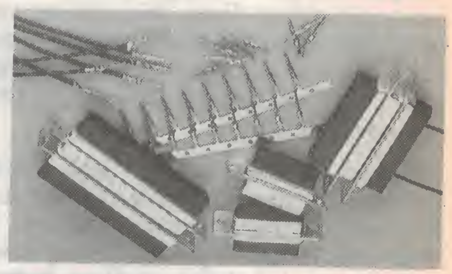
For further information contact Procon Technology, PO Box 43, Essendon 3040, phone (03) 336 4956.

Digital panel meter catalog

A brand new 18 page Lascar catalog is available from the Australian representative, Jaycar Electronics. The catalog features the latest surface mount technology DPM's from Lascar – the world's leading DPM manufacturer.

Panel meters are available in both liquid crystal and LED-type displays. All DPM's come complete with snap-on bezels. Full technical information is provided for the 50-odd products described.

Contact Jaycar branches or the head office at 115 Parramatta Rd, Concord 2137, phone (02) 747 2022, for a free copy of the catalog.



DB connectors

Utilux now offers the Australian market one of the most comprehensive and competitively priced ranges of DB connectors available. The range embraces connectors with crimp removable contacts, insulation displacement plugs and receptacles, accessories and PC board receptacles.

The crimp removable connectors of the Utilux (Molex) range are available in 9 to 50 circuits and are usable with all standard accessories. Crimp contacts are available in either loose or reel form with three styles of selective gold plat-

ing which accommodate conductors of 20 to 28 AWG.

Accessories include plastic and metallised hoods for use with screwlocks, cable back shells for clip and retainer attachment and, a slide latch assembly. Utilux can supply hand crimp tools and semi-automatic machines to suit and also have the facility to supply customised ribbon cable assemblies using the Molex range of DB connectors and ribbon cable.

For further information contact Utilux Electronics Division at Kingsgrove NSW , phone (02) 50 0155.

Dual band transceiver

Icom has released the IC-32AT, a hand-held FM transceiver, featuring dual band operation.

Not only can the IC-32AT operate over the entire 144-148MHz and 430-440MHz bands, but it can transmit on one band and simultaneously receive on the other – true full duplex operation with telephone convenience. One frequency from each band can be stored in each of the 20 dual storage memory channels for simplex or instant duplex operation, allowing the unit to scan all 40 memories, all 2 metre memories or all 70cm memories with the IC-32AT's versatile programmed scan facility.

An advanced priority function allows the user to call channel memory, any selected memory channel or all memory channels every five seconds, even while operating. Using a custom-designed dual-band final amplifier power module, the tiny IC-32AT generates a full 5.5 watts output on 2 metre and 5 watts on 70cm.

As well, the optional UT-40 tone squelch unit runs the IC-32AT into a personal pocket pager, emitting a 30 second alarm when the selected tone frequency is received.

For further information contact Icom Australia Pty Ltd.,7 Duke St, Windsor 3181, phone (03) 529 7582.

Hand-held oscilloscopes

Tektronix has announced the availability of two new hand-held digital storage oscilloscopes (DSOs).

The new T200 scopes are targeted at field service engineers and technicians, but are ideal for anyone needing a lightweight, compact oscilloscope for troubleshooting design or service problems. To date, these scopes are being used to test and repair such diverse products as biomedical instrumentations, burglar alarm systems, elevators, and process plant machinery.

The T200 oscilloscopes capitalise on flat panel LCD technology and digital capabilities to achieve their small size and portability, but offer the performance and feature set of full-sized digital storage oscilloscopes.

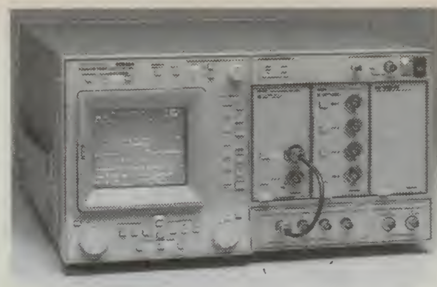
For further information contact Tektronix, 80 Waterloo Road, North Ryde 2113, phone (02) 888 7066.

Disk interchange

Minicomp now has available the SMT (Systems Manufacturing Technology) Interchange. The SMT Interchange is a bi-directional means of transferring data from one format to another. It has the ability to go from 5.25″ to 3.5″ disk drives or from hard disk to hard disk or vice versa. The interchange does as its name suggests: it acts as a crossroad to facilitate moving data from a PC, XT, AT, to a PS/2 or portable.

SMT Interchange consists of a 3 metre cable, with plugs (Centronics) at each end. Also provided is special software on disk (both 5.25″ and 3.5″) which does the uplifting on one computer and downloading on the other computer. Recommended retail price of the Interchange is $95.00 (incl. tax).

Further information from Minicomp, 104-108 Mount Street, North Sydney 2020 or phone (02) 957 6800.



Counter-timer scope

Tektronix has introduced two analog oscilloscopes with a built-in 750MHz, 10-digit count-timer, video triggering expanded automatic pulse parameter measurements and non-volatile RAM for storing test setups.

The 11301A and 11302A feature 400 and 500MHz of bandwidth respectively. The 11302A achieves an exceptionally bright display, via its use of Tektronix' Micro Channel Plate CRT (a proprietary photon-multiplier technology) for viewing low repetition rate signals and hunting for glitches.

In addition, the 11301A and 11302A feature eight-channel display capabilities, automatic signal displays and interactive touch-screen interfaces.

Further information is available from Tektronix Australia, 80 Waterloo Road, North Ryde 2113 or phone (02) 888 7066.

Digital capacitance meter

A useful service instrument designed to measure capacitor values from 0.1pF to 20,000uF has been released by Wagner Electronics.

The DM6023 has an easy to use nine range push button front panel switch, allowing quick direct measurement. Design considerations of high reliability and durability were achieved using LSI circuitry.

Accuracy is provided from a crystal timebase generator and fast sampling. Protective measures such as a circuit to prevent damage from charged capacitors are included.

The DM6023 is most accurate on the lowest capacitance range. Up to 200pF the digitally displayed 0.1pF increments are accurate to ±0.5%. Accuracy is down to a respectable ±2.0% on the 20,000uF range. This precision portable capacitance meter is only $149.

Available from Wagner Electronics, 305 Liverpool Rd, Ashfield 2131 or phone (02) 798 9233.

New Products

AC voltage standard

Claimed to represent a significant improvement in the state of the art, the Ballantine model 6400A AC voltage standard delivers AC voltages from 1 nanovolt to 1000V with an amplitude uncertainty of no more than 32 parts per million between 40Hz and 20kHz. The standard, which can be programmed over the IEEE-488 interface bus, has an uncertainty of only 475 ppm at 1MHz.

The achievement of these levels of precision has hitherto required the use of AC-DC transfer standards with their concomitant slow and tedious measurement procedures. Unlike transfer standards, which are actually devices for making comparisons, the 6400A is a true voltage standard. Its output is a very clean sine wave, the frequency of which can be set with 1 ppm precision on each of its seven ranges, which extend from 1mV full scale to 1000V.

Because of its combination of simple operation and extremely high accuracy, the Ballantine 6400A is the first AC standard that allows the latest generation of precision AC voltmeters to be quickly and precisely calibrated.

For further information on the 6400A contact The Dindima Group, PO Box 106, Vermont 3133 or phone (03) 873 4455.

Radio log program

Amateur radio operators can now save time logging their contacts on computer instead of the old longhand method. A recently introduced IBM PC compatible program, titled Logmaster, is one such program that adds power to a computerised ham shack.

Logmaster allows entry and tracking of all contacts using a simple menu driven screen. Once entered, there are a number of valuable functions available. Logmaster even handles duplicate logging to simplify contest scoring.

This handy, time saving program is available from Dick Smith stores for only $99 (Cat.X-9702).

Impedance analyser

Tech-Sales announces the new Solartron 1260 Impedance Analyser, recently launched by U.K. based Solartron Schlumberger.

The 126 offers gain, phase, group delay and impedance measurements over a frequency range 10 microhertz to 32 megahertz.

Input signals on two independent voltage channels and one current channel are analysed using a single sine correlation technique to provide fast and precise measurements of phase and gain. The built-in voltage or current generator offers frequency, amplitude and bias sweep facilities. IEEE and RS232 interfaces allow remote operation and output of results to a printer or digital plotter.

The performance of the 1260 is optimised for testing materials, measuring and analysing components or electronic circuits, and studying transmission or network characteristics.

For further information contact Tech-Sales, 12 Maroondah Highway, Ringwood 3134 or phone (03) 879 2266.

Low profile DIL switch

The new low profile A3000 series DIL switch, from Siemens can be picked, placed and soldered fully automatically and is immersion-washproof. Penetration of solder flux and cleaning agents to the contact area is prevented by means of a self-adhesive cover on the top of the switch, which is removed after washing.

Other features include:

- High contrast "on" and "number" captions.
- Stationary contact with wiping action.
- Available in plug-in and surface mount (type 2 preferred version).
- Packaged in bar form for automatic assembly.
- Standard sizes 4, 5, 8 & 10 way, other size available on request.
- Approved for use in Telecom equipment.

Further information from Siemens Components Division, 544 Church Street, Richmond 3121 or phone (03) 420 7111.

Suppression capacitors

To assist design engineers involved in EMI/RFI suppression work, Rifa has introduced a Lab Kit covering a selection of their wide range of specialised suppression capacitors. The kit is supplied in an attractive briefcase with over 200 capacitors covering delta, single capacitors as well as RC networks.

Rifa suppression capacitors employ metallised paper construction giving them very high dv/dt ratings and enabling them to withstand high surge voltages in the most demanding of applications.

Further information from Rifa, 202 Bell Street, Preston 3072 or phone (03) 480 1211.

Battery has 10 year life

A long-life RE (Recombination Electrolyte) battery with a proven track record overseas has just been made widely available in Australia by Dunlop Batteries. The Powersafe, say the manufacturers, has a life of at least 10 years under normal duty.

This, plus the battery's high energy density and minimal maintenance has made the Powersafe popular, particularly with the telecommunication industry. According to user reports, the trouble-free period of a Powersafe cell matches that of the highly reliable electronic support systems in telephone exchanges.

No topping up and no maintenance are additional Powersafe benefits, which flow from a design that recombines gases back into the liquid state almost the instant they are formed during discharge.

Capacities of the Powersafe range extend from 30 to 450 ampere-hours at the 10 hour rate. Powersafe monoblocs are available in 4, 6, 10 and 12 volts in sizes to suit virtually every situation.

Further information is available from Pacific Dunlop Batteries Industrial, 55 Byrant St, Padstow 2211, phone (02) 774 0500.

Letters

Continued from page 5

ard may be unkown to readers also – and to wives and children who may use a similar kind of resin and catalyst when working with fibreglass or hardeners used in liquid casting plastic.

So before using any of these catalysts, check their chemical composition and take appropriate precautions. The cost of a pair of safety goggles is a very small price to pay for the protection of eyesight.

(With acknowledgement to American Airlines.)

Circuit symbols

I am employed in the TAFE sector of RMIT and some of my teaching within the Certificate of Technology – Electrical course is in the area of electrical drafting.

A student showed me your article "How to read circuit diagrams", which appeared in the April 1988 issue and I wish to offer the following comments.

It is disappointing to see old-fashioned symbols being presented to the newcomer in electronics. The symbols shown in Fig. 1 and 2 appear similar to those used widely fifteen years ago. However, symbols published by the Standards Association of Australia and by International Standards Organisations have changed markedly over this period.

Courses conducted by TAFE Colleges incorporate current Australian standards and students studying such courses are directed to these standards by study guides or syllabus documents.

I have found over a number of years teaching electrical drafting subjects, that many students are confused by the different symbols used in electronics magazines to those shown in the standards. Unfortunately your article may well add to that confusion.

I would agree that not every individual/firm/organisation involved in the production of drawings would use Australian standard symbols, and that technical personnel need to be aware of other symbols.

However, your article is directed to the newcomer and it is my belief that these people should be presented with current Australian standard symbols. It is just possible, through education of the newcomer to a standard set of symbols, that one day we may all be using the same symbols.

Terry Clement
Acting Head of Department
Electrical Technology, RMIT
Melbourne, VIC

Comment: Thanks for your views. We are not unaware of the SAA/IEC standard symbols, but as explained in "Forum" for October we choose not to use them. Rather than help the newcomer, we believe they'd do just the opposite – and a lot of other magazines seem to agree with us.

Super Timer

Continued from page 74

to 103 miles per hour. A second drive gave a speed of 87 mph. Must have been getting tired! The measuring apparatus certainly was.

The thyristor based timer control was particularly effective and performed without fault during the various tests.

The timer can make many kinds of measurements with the highest accuracy. It is very effective for obtaining or confirming (useless?) information, and poses a challenge to the designer to produce the endless range of triggering devices required to make timing measurements, particularly over short distances or short intervals. Try making triggers to measure the speed of a slot car or radio controlled model!

Superhet receivers

Continued from page 144

chapter are eminently successful in their chosen field as stated. However for the reception of weak distant transmitters such as amateur stations over distances of thousands of kilometres, or (over shorter range) CB broadcasts, mobile transmitters or any of the myriad low-power transmitters that are part of our present day business and professional life, still more advanced superheterodyne receivers are necessary.

The highest class of superheterodynes are called 'communications receivers', having many advanced features, more controls and sometimes radically different types of intermediate stages.

Such special receivers are capable of extremely narrow bandwidth, so that stations very close in frequency can be successfully separated and received. Also sophisticated AGC and 'noise blanking' circuits may be used, and sometimes automatic digital computer-controlled tuning and logging are featured.

If that has just whet your appetite, discussion of such advanced features must wait until another episode. For now, bye!

Hobby contest

Continued from page 45

'Beat Me', and designed so that its beat rate is set merely by tapping on its case, at the desired rate. It was again neatly housed in a medium-sized Jiffy box.

Mr Agius' entry was a Sprinkler Timer Unit for lawn watering systems, designed to control the watering of up to 14 different lawn 'sectors' using two solenoid valves and commercially available 'Distributor Taps'.

Both designs were creative, imaginative and used readily available parts. The Judges decided that they again had slightly wider appeal than the other entries, and therefore awarded both Paul Thompson and Tony Agius the runner-up prizes of DSE Component Vouchers worth $100 each.

As in the other section, however, the Judges also awarded a special commendation. This was to Mr T.C. Madden, of 3 Jingara Court, Karana Downs Queensland, whose entry was a UHF Amplifier for TV Reception. This used all discrete parts, housed in a tinplate box made from a tinned-fruit can, and the Judges liked its 'roll your own' experimental approach.

Our congratulations to all of the prize winners, and commiserations to those whose entries didn't qualify for a prize. As noted earlier, we hope to publish both the prizewinning entries and many of the other designs in the coming months – so keep an eye out for them.

Product Review:

Goldstar's DM-6335 'pocket wonder' DMM

If you're still harbouring any vague fears about the quality of test equipment from Korea, the new Goldstar DM-6335 should finally put them to rest. Very nicely made and surprisingly sturdy, it will literally slip into a shirt pocket.

The first digital multimeters that came out were the size of a suitcase, with a weight that made them 'transportable' rather than portable. They had an equally staggering price tag, too, even though in many cases they weren't all that stable.

Since then, they've been steadily shrinking in size, weight and price – another good example of the benefits of galloping VLSI integrated circuit technology. At the same time, the performance has been steadily improving, to the point where now even the cheapest models tend to provide more ranges, higher resolution and greater stability than most of those high-priced early models.

It's also not long ago that electronic equipment of any kind made in Korea had a reputation for dubious quality and reliability. This applied even to commodity items like transistor radios, let alone more specialised 'up market' items like digital multimeters and other test equipment. But nowadays the Koreans have lifted their game considerably – to the point where quite a lot of equipment from reputable Japanese firms is actually made there, under contract.

As with Taiwan, it's the story of 'Japan, Inc' all over again.

Judging by the new DM-6335 pocket multimeter, Goldstar Precision has certainly mastered the art of producing high-grade test equipment in an efficient and cost-effective fashion. Considering its recommended retail price of less than $120, it offers an impressive combination of features and performance in a package measuring only 148 x 66 x 25mm.

It's a 3-1/2 digit instrument, with a maximum count of 1999. The liquid-crystal display has digits a generous 10mm high, and has good contrast for easy readability. Along with the actual measurement readout the LCD also displays the current units of measurement and various indicator flags to remind you of any special functions in operation.

It provides some 18 ranges in all. There are 5 DC voltage ranges, with FSR values of 200mV, 2V, 20V, 200V and 1000V and resolution ranging from 100uV to 1V. Rated basic accuracy on these ranges is +/-(0.5% + 1 digit).

The AC voltage range is a little smaller, with only 4 ranges having FSR values of 2V, 20V, 200V and 750V, and resolutions from 1mV to 1V. Rated accuracy of these ranges is +/-(0.75% + 5 digits). Input impedance for both DC and AC voltage measurements is 10M, with overload protection capable of withstanding 1100V DC or AC peak for up to 60 seconds.

There are only two current ranges each for DC and AC, in each case with FSR values of 200mA and 10A. But this works out better than you might think, because the resolution on the 200mA ranges is 100uA while that on the 10A ranges is 10mA. So from a practical point of view, most current levels found in the majority of electronic gear can be measured quite accurately.

Rated accuracy on the 200mA ranges is +/-(0.75% + 1 digit) for DC, and +/-(1% + 5 digits) for AC. The corresponding figures for the 10A ranges are +/-(1.5% + 5 digits) and +/-(2% + 7 digits). The overload protection can cope with 400mA on the 200mA ranges for 60 seconds, and 13A for 40 seconds on the 10A ranges.

Finally there are 5 resistance ranges, with FSR values from 200 ohms to 2M in 10:1 ratios, and resolutions from 100 milliohms to 1k. The rated accuracy for these ranges is +/-(0.75% + 1 digit). An additional feature here is that a voltage limiting circuit can be switched in if desired, to keep the voltage across the test circuit below 450mV. This allows convenient checking of diodes, transistors and other semiconductor devices (and also circuitry around them).

The overload protection operating for resistance measurement can cope with 500V DC or 350V AC RMS, with no specified time limit.

So much for the basic instrument. But like many of the latest instruments, the DM-6335 provides a number of additional features. One of these is autoranging, which can also be disabled if you wish to set the range manually and have it stay on that range. Another feature is a 'Hold' or storage button, which forces the instrument to stop sampling and hold the last reading (handy for extricating yourself from something before you consider the implications of the measurement).

Both of these are fairly standard, of course, but the DM-6335 also offers another function that's not so common: a '-Mem' button, which causes the instrument to memorise the two most significant digits of the measurement, and subtract that figure from all subsequent measurements (until either the function is disabled, or you change range).

The idea of this function is that it allows you to memorise a reading, and then automatically display the *deviation* of subsequent measurements from that value. Very handy for measuring drift, or voltage regulation of a power supply!

It also allows you to compensate for probe and measuring lead resistance, on the lowest resistance range.

Incidentally the DM-6335 also con-

tains a small piezo buzzer, which 'beeps' at various times to draw your attention to overload conditions, to acknowledge that you have pressed a control button and so on. It also sounds continuously on the resistance ranges when the measured value is less than 2% of FSR, providing a 'continuity test' function for checking wiring.

Checking it out

I tried out the sample DM-6335 over a couple of weeks, making a fairly wide range of measurements. It turned out to be very easy to use, with no recognisable 'vices' at all.

We don't have access to fancy calibration gear at present, but measurement comparisons with other instruments of known accuracy and reliability suggested that the voltage and current ranges were well within the rated specs. Checks of the resistance ranges with some precision reference resistors showed the same for these, so performance-wise the DM-6335 checked out fine.

Mechanically, it proved to be surprisingly rugged in construction – considering its compact size. A peek inside confirmed that the case was a quality moulding, with solid internal fillets and support/assembly pillars.

Essentially the complete circuitry of the instrument is packaged in a single VLSI chip, apart from the LCD display, the piezo sounder and a few support components. Everything is mounted on a neat double-sided PCB with plated-through holes, except for the LCD which is a separate sub-assembly attaching to the board with four screws. The connections to this are made via a conductive-plastic connector strip, mating with a set of pads on the front of the board.

Even the 'works' of the rotary selector switch are an assembly mounted on the PCB, with the control knob shaft having flats and passing through a slot in the centre. An elegant approach, and one that allows the complete unit to be disassembled and re-assembled easily if servicing is required.

Needless to say, the test probe input sockets are fully recessed to prevent accidental contact and shock. The DM-6335 comes with a matching pair of test probes, with shrouded plugs at the meter end and shrouded alligator clips which screw onto the test prods over the needle tips. There's also a small user manual, with a tiny circuit schematic at the rear to facilitate servicing (if you have a suitable magnifying glass!).

On the whole, the DM-6335 gives every evidence of being well designed, carefully made using quality parts and therefore likely to give reliable service. For the quoted RRP of $118.80 it therefore seems to provide excellent value for money.

Like other instruments in the Goldstar range, it is available from a network of dealers throughout the country. You'll find a complete list in current Goldstar ads, showing the one nearest you. (J.R.)

Superheterodyne Receivers

This month we meet the superheterodyne receiver, which can have exceptionally high sensitivity and sharp selectivity – essential requirements for the reception of distant radio stations.

by BRYAN MAHER

The TRF receivers we considered last month were simple, basic but limited in performance. They lack *sensitivity*, and hence do not have enough gain to 'pull in' distant stations. Also TRF receivers have insufficient *selectivity*, so they have trouble separating the many strong local stations in a large city.

To overcome these deficiencies, in 1918 Major Edwin H. Armstrong invented a radical new idea, the *superheterodyne* receiver. The word 'heterodyning' means the act of beating two different frequencies together, working to obtain a third frequency as in Fig.1. (hetero = different; dyne = work).

TRF deficiencies

To see why we would bother to increase the complication of radio receivers, compared to the relatively simple TRF receiver discussed last month, it appears that the greatest shortcomings of the TRF receiver stem from two facts. In TRF receivers:

1. When tuned to a station the TRF receiver circuits are all tuned to the same frequency.
2. The frequency to which they are all tuned must be continuously variable.

Tuning many circuits to the one frequency runs the risk that accidental coupling via the power supply lines or stray capacitance can couple output radio frequency (RF) signal back to the sensitive input of the tuned stages or to the antenna, causing instability.

In an unstable condition a receiver screams, whistles its head off and is quite useless.

The design of continuously variable circuits initially required large ganged variable capacitors, as we saw last month. These have such massive metal components that stray capacitive coupling from one section to another is a natural, though unwanted consequence.

Because of this effect the variable tuned circuits cannot be designed to have very high gain, nor can too many stages be used, or unstable oscillatory conditions will inevitably occur.

Thus sensitive high gain TRF receivers are an impossibility. The lack of selectivity of TRF receivers stems both from the above limit on the number of tuned stages and also from another rather subtle effect – the change in bandwidth of a tuned circuit as we tune it across its variable frequency range.

Recall that earlier in this series we defined the *quality factor* 'Q' of a tuned circuit as:

$$Q = (2Pi\ f\ L)/R$$

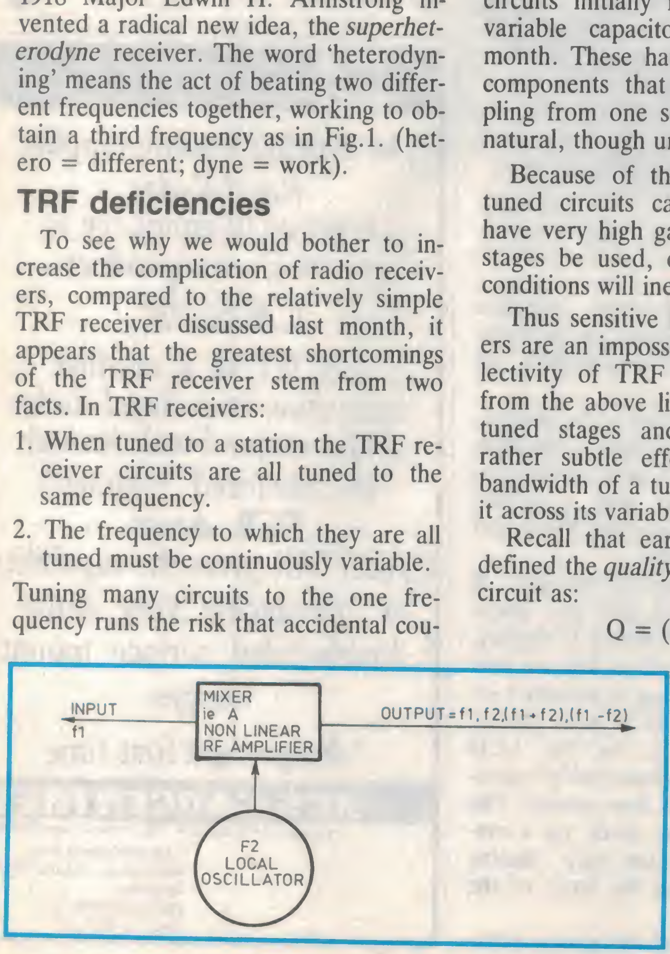


Fig.1: The basic idea of heterodyning. A local oscillator at frequency F2 beats with the input frequency, producing sum and difference signals.

where Pi is 3.1416; f is the frequency in Hz to which the circuit is tuned; L is the inductance of the tuned coil in henries; and R is a quantity in ohms representing all losses of the tuned circuit.

Despite this definition it is found in practice that the Q of a tuned circuit hardly changes at all as we tune it across its frequency range.

The reason for this unexpected state of affairs is that while the inductance L remains mostly constant, as the frequency is increased we find that the circuit losses R also increase. This is because R is much more that the simple DC resistance of the coil.

R represents a conglomerate effect summarising all the tuned circuit power losses, which includes dielectric shunt resistive losses of the capacitors and all the insulating materials; these power losses increase at higher frequencies. R also includes the series resistance of the coil, wiring and capacitors; these resistances increase at higher frequencies.

Skin effect

This increase in series resistance is called the *skin effect*, as at high frequencies currents are pushed out of the centre of the conductor by their magnetic field, and are forced to flow only near the surface of the conductor. With less effective cross sectional area the conductor appears to have higher resistance to high frequency currents.

So the losses symbolized by R increase roughly in proportion to frequency, with the result that Q remains almost unchanged as we tune across the dial.

But we also said earlier that Q relates the bandwidth 'delta f' of a circuit to its tuned frequency:

$$Q = f/(\text{delta } f)$$

as Fig.2 shows. (The Greek symbol delta is used to mean 'a small change in a value').

But as Q does not change when the

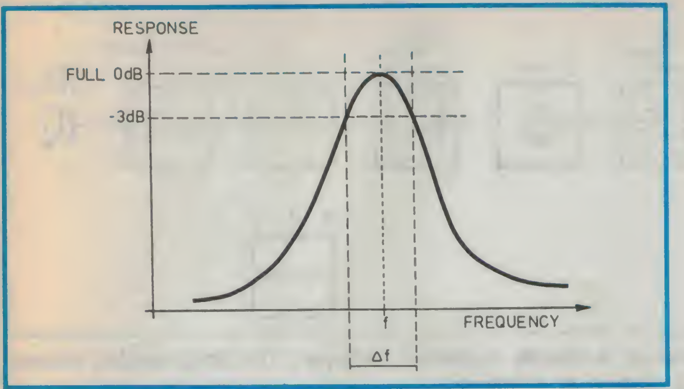


Fig.2: A reminder about the response of a tuned circuit. The higher the Q, the narrower the curve.

TABLE 1: Superhet frequencies

Station and mixer tuning f1 (kHz)	Local Osc f2 (kHz)	IF = (f2-f1) (kHz)
500	955	455
750	1205	455
1000	1455	455
1200	1655	455
1350	1805	455
1500	1955	455

Table 1: How the local oscillator 'tracks' the signal, to produce a constant IF.

tuned frequency f is increased, it must be that the bandwidth (delta f) also increases. This is why it is impossible to design narrow bandwidth variable-tuned circuits for high frequencies. The bandwidth is different when tuned to different stations. For a broadcast band (500 to 1500kHz) TRF receiver the bandwidth typically increases by a factor of three across the dial.

Enter the superhet

To conquer these deficiencies, which are inherent in all TRF receivers, Major Armstrong proposed a radical new idea, the superheterodyne or 'supersonic heterodyne' receiver as shown in the block diagram of Fig.3.

The antenna feeds signals at chosen station frequency f1 to a non-linear 'mixer' RF amplifier stage. Also fed into the mixer are RF signals at a different frequency f2, from a 'local oscillator' (LO). The local oscillator signals are large enough in amplitude to drive the mixer into the necessary non-linear mode of operation.

Four output frequencies are possible from the mixer stage. These are f1, f2, (f1+f2) and (f1-f2).

Following the mixer is an *intermediate frequency* or 'IF' amplifier stage, fixed-tuned to frequency (f1-f2) and rejecting the other three frequencies f1, f2 and (f1+f2).

Both the mixer and local oscillator are variable tuned, but ganged and designed in such a way that as they are tuned across their frequency range, the *difference* in frequency (f1-f2) remains constant. This has the effect that whichever RF signal may be tuned is converted into a fixed and lower-frequency IF signal, which carries the same modulation as the original received RF signal.

The whole idea of superheterodynes is that, as the intermediate frequency amplifier stages are tuned to a fixed frequency, the IF tuned circuits can be made small, compact, with both coil and fixed tuning capacitor within one metal shield can. This completely shielded construction allows a number of intermediate amplifier tuned stages to be used.

Although all IF stages are tuned to the one frequency, stage gain can be made quite high without instability, by the complete shielding and isolation of each IF tuned circuit.

The intermediate frequency tuned circuits are called IF transformers. These can use mica dielectric tuning capacitors, or fixed capacitors with adjustable ferrite 'cores' in the transformers to perform the tuning. Either way, they can be quite small.

Sharper tuning

The design and construction of these small compact IF transformers achieves a higher Q, sharper tuning and narrower bandwidth than can be realized with variable-tuned circuits such as are used in the mixer stage. Therefore with this superheterodyne arrangement, most of the receiver's selectivity is attributable to the fixed-tuned IF stages.

But as the IF is a constant frequency, the bandwidth does not change much as we tune across the frequency range. As many IF stages can safely be used, quite narrow bandwidth (i.e., high selectivity) can be achieved.

Choice of IF

Once set up, the idea is that the intermediate frequency is a constant.

To avoid any problems of station transmissions interfering with the IF signals, a number of standard IF frequencies have been agreed by manufacturers and governments and few if any radio transmitting stations are allowed on these chosen frequencies. A receiver designer chooses one of these standards for his IF frequency.

The frequencies 175kHz, 455kHz, 3.3MHz, 9.0MHz, 10.7MHz and 45.75MHz are regarded as reserved frequencies for IF use. Most AM broadcast receivers use 455kHz for their IF.

In general the lower the intermediate frequency chosen for a receiver, the greater the selectivity, i.e., the narrower the overall receiver bandwidth.

Though the superheterodyne principle immediately disposes of the low sensitivity and selectivity problems inherent in all TRF receivers, it can bring some new difficulties of its own. But whoa – one thing at a time!

Firstly Fig.3 shows the frequencies used to tune a station on 1000kHz. The mixer input circuit is tuned to the station frequency on 1000kHz, while the local oscillator (or LO) is tuned to 1455kHz. The heterodyning or 'beat' effect yields a difference of (1455-1000) = 455kHz, which becomes the intermedi-

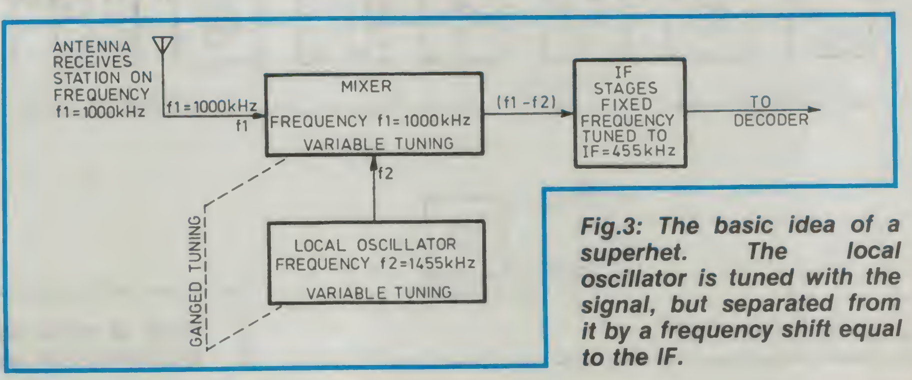


Fig.3: The basic idea of a superhet. The local oscillator is tuned with the signal, but separated from it by a frequency shift equal to the IF.

ate frequency or IF.

A range of frequencies used as the receiver is tuned over the broadcast band would be as shown in Table 1. Notice that while f1 changes over 3:1 range, f2 changes over a lesser range (1955/955kHz = 2.05:1).

Padding & trimming

Before you retort 'So what?', consider that the mixer tuning and local oscillator tuning are both operated by the one tuning dial drive mechanism and knob. The common arrangement is a two-gang tuning capacitor, with one section for the mixer RF tuning and the other for the local oscillator.

But as f1 and f2 must change over a different range, some tricks of circuit design must be used. One method is to use a *padder* capacitor in series with the oscillator tuning capacitor, to shorten its tuning range.

To bring all of the tuned circuits into alignment, small semi-variable capacitors in parallel with the mixer and local oscillator tuning capacitors are 'trimmed' to bring the IF frequency to the required figure – e.g., 455kHz.

Further separate trimming capacitors or *trimmers* may be used to bring all IF tuned transformers to exactly the same frequency. Alternatively adjustable screw-type ferrite cores may be used, as mentioned earlier.

Once this 'lining up' procedure is done, all padding and trimming adjustments are sealed and not moved again.

Any subsequent repairs to the circuit or replacement or components may require re-adjustment of padders and trimmers. For this reason the sealing compounds used are semi-permanent materials, rather than permanent paints or glues.

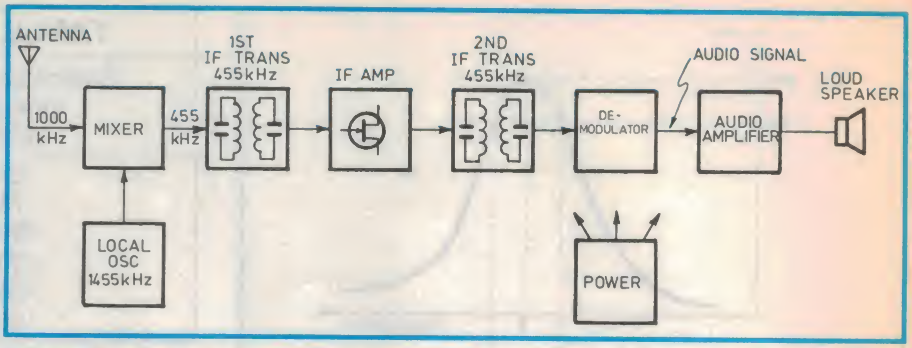


Fig.4: Block diagram of a simple superhet receiver. The frequencies shown are when tuned to a station at 1000kHz.

The basic superhet

Radio receivers intended for city and suburban reception (where station field strength is high) do not need much sensitivity, but still require adequate selectivity because there may be many stations to be separated.

For this very common application a receiver can be implemented using one IF stage, involving one IF amplifier transistor and two tuned IF transformers. Preceding this would be a mixer stage tuned to the station, and of course the local oscillator as in Fig.4.

Such a lineup of stages would be an economy receiver, satisfactory for 'local' reception only, where many powerful stations are located within 50km or so and the owner has no wish for long distance reception.

Radio receivers of this basic superheterodyne type sell for a range of prices from $10 upwards, and millions have been manufactured and sold as most Australians are city or suburban dwellers. Many have also been home-constructed over the years by readers of *Electronics Australia* using designs published in this magazine, and often from the associated kits.

Greater complexity

Away from the cities there are many different applications where people live at distances of 100 to 250 kilometres from their nearest 'local' station. Radio receivers for such use need more sensitivity than can be achieved using the basic superhet of Fig.4.

Also there are listeners who wish for reception of some of the more powerful AM stations on frequencies in the 3.0MHz to 30MHz range, and national transmitters like Radio Australia, Voice of America, Deuschland Speigel, the BBC and so on.

For such receivers better selectivity is mandatory, because the extra sensitivity will pull in many stations from far and near, some of which will be very close in frequency, stretching the receiver's ability to separate them.

These receivers are more complex,

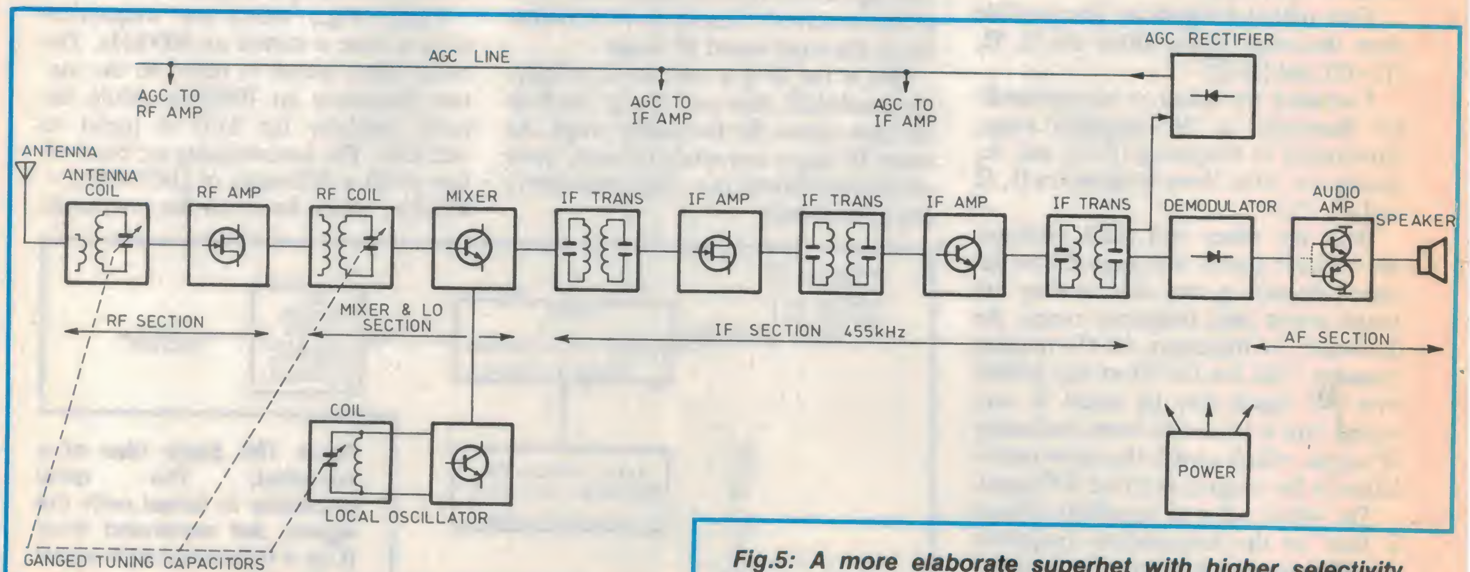


Fig.5: A more elaborate superhet with higher selectivity and sensitivity, also fitted with AGC.

using two or three IF amplifier stages involving three or four IF transformers, as sketched in the block diagram Fig.5.

Such multi-band receivers incorporate some sort of band-switching (or 'wave-change switch' to use a very old name), so that two or more sets of tuning coils can be switched, one set for the medium-wave broadcast band and the other(s) for the HF or 'short-wave' band(s). Some of the more expensive receivers have three or four sets of coils to cover the various bands.

In each case the high gain and sharp selectivity of the intermediate amplifier stages plays an essential role in the reception, the receiver responding to the very weak signal and successfully separating the many stations.

Optional RF stage

For a number of reasons, a high-performance superhet receiver may also include a tuned radio frequency amplifier stage ahead of the mixer, as shown in Fig.5. Such an RF amplifier must of course be variable-tuned, its tuning ganged with the mixer and local oscillator tuning, all being operated by the common tuning dial. If tuned by variable capacitance a three-gang variable tuning capacitor would be required.

One reason for including an RF stage in a high-performance receiver is to allow *automatic gain control* (AGC) of the RF signal ahead of the mixer, to prevent overloading on very strong signals. A second reason applies to long-distance reception, for a mixer circuit is usually less noisy when fed with a fairly strong RF signal.

There is a third important reason favouring the inclusion of an RF stage (and occasionally two RF stages) ahead of the mixer, but that reason is a topic for a whole future episode in this series.

Many designs

Literally hundreds of variations of the basic superheterodyne principle have been designed and built world-wide in the seventy years since Major Armstrong's day.

Superheterodyne receivers are the most successful and widely used type of radio and television receivers, with frequency ranges covering most of the spectrum from VLF all the way up to UHF.

Quite a number of different types for various applications in domestic, hi-fi and amateur service have been featured in this magazine, both under its present name *Electronics Australia*, and its previous names *Radio, TV and Hobbies*, *Radio and Hobbies*, and earlier still *Wireless Weekly*.

Demodulation

As indicated in Figs.4 and 5, in all these AM receivers the output of the last IF transformer feeds the AM demodulator or *detector*, where the audio component (i.e., the music and speech) is extracted from the modulated carrier. Many types of demodulator are possible, the simplest and most common being the diode detector as described in detail in the previous episode.

Following the demodulator the audio signal passes through the volume control, then on to the audio amplifier stages.

Audio amplifier

The audio amplifier stages of radio receivers come in all shapes and sizes, and in a wide range of power capabilities. You will find some radio receivers whose audio stages are simple, cheap and capable of only mediocre audio response. Then there are radios whose audio stages are excellent designs, producing music quality truly classed as hi-fi.

The power output capability of contempory designs in audio amplifier stages for radios cover a wide range. You'll find anything from about 100 milliwatts output for driving headphones, all the way up to 100 watts of hi-fi stereo music intended to drive multiple loudspeakers in lounge rooms or in automobiles.

Just one of the hundreds of possible designs for a suitable audio section is shown in Fig.6. This circuit raises the audio signal level to an amplitude and power sufficient to drive a loudspeaker or perhaps a pair of earphones. Of course we will want a volume control too.

The first stage in Fig.6 is often called the audio 'voltage' amplifier, preceded by the volume control. The second stage is the audio 'power' amplifier, suitable for driving a loudspeaker. In this case it can do so to moderate volume, and with not exactly 'hi-fi' quality – more like 'medium-fi'.

The volume control is usually placed ahead of the audio amplifier, so that the audio stages will not be overloaded on strong signals.

Fig.6 uses a so-called *logarithmic* volume control (to avoid any abrupt control action) followed by a LM741 op-amp as a voltage amplifier with a voltage gain of 6, after which comes an LH0021CK power amplifier whose voltage gain is also set at 6. Thus a 400 millivolt audio signal from the volume control will give full power output of +/-14.4 volts peak (on light loads) or +/-11 volts at output currents up to 1.0 amp.

The safe output power into a loudspeaker load is limited by the type of heatsink to which the LH0021CK is attached. With an effective heatsink, output power up to 8 watts into an 8 ohm loudspeaker is quite easily obtained.

More information on audio voltage and power amplifiers in general is contained in my book 'Op Amps Explained', available by mail order from *Electronics Australia*.

Power supplies

Naturally power supplies for all the sections of the radio circuits shown must be provided. Either one (or more) batteries or a mains transformer and rectifier and filter would be used.

A power transformer stepping down the 240 volt mains to a suitable low voltage around 15 volts, a bridge rectifier and a few large electrolytic capacitors may constitute the simplest possible mains power supply.

To obtain improved results and reduce mains hum sometimes the power supply voltages are held steady (despite mains voltage fluctuations) by the simple application of voltage regulators, either zener diodes or integrated circuit feedback voltage regulators.

More information on power supplies and voltage regulators will also be found in my book 'Op Amps Explained'.

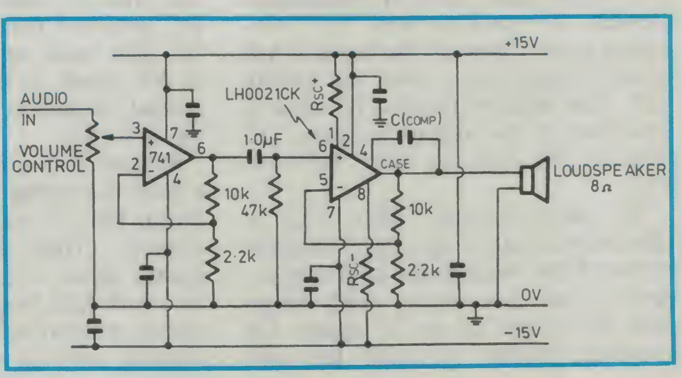


Fig.6: One of the many possible configurations for the audio amplifier section of a receiver.

Superhet receivers

Improvements

That completes the essential parts of a superheterodyne radio receiver for the reception of amplitude modulated (AM) signals. A superhet design may be quite simple, or it may include one or more embellishments to improve the performance, compensating for the shortcomings of atmospheric radio transmission.

The limitations of transmission reveal that in many locations the signal received from the station does not remain constant in amplitude, rather it fades up and down at both very low rates (i.e., stronger at night time) and also high rates (i.e., fluttering signal strength).

Both slow and fast changes in signal strength are caused by the nature of the atmospheric propagation of electromagnetic radiation, especially over long distances.

Automatic gain control

The first improvement we make to our basic radio receiver is to add *automatic gain control*, or AGC circuits. In earlier years this was called 'automatic volume control' or AVC.

Recall that the carrier signal in the frequency domain picture (refer to Fig.7(b) last month) gives us no speech, music nor any information except the fact that the station is transmitting. However we can deduce from the carrier the station frequency, and the signal strength as received at our location. When the signal fades up and down, it is the received RF amplitude of both carrier and sidebands which is changing.

Automatic gain control circuits make use of the IF signal at the output from the final intermediate amplifier. The AGC circuits most commonly used rectify this IF signal to obtain only the negative half of the modulated IF signal, and smooth it out to obtain the average (negative) DC component, using a circuit such as Fig.7.

A second small secondary winding L21 on the final tuned IF transformer provides IF signal to diode D21, connected so as to pass all the negative half of the IF signal but to block the positive half. This negative rectified IF signal is smoothed to the average negative DC level by the low-pass filter R22 and C21.

The time constant, (R22 C21) is chosen to be quite long, longer than the period of the lowest audio frequency expected, and thus much, much longer than the period of the IF signal. For broadcast station reception the time

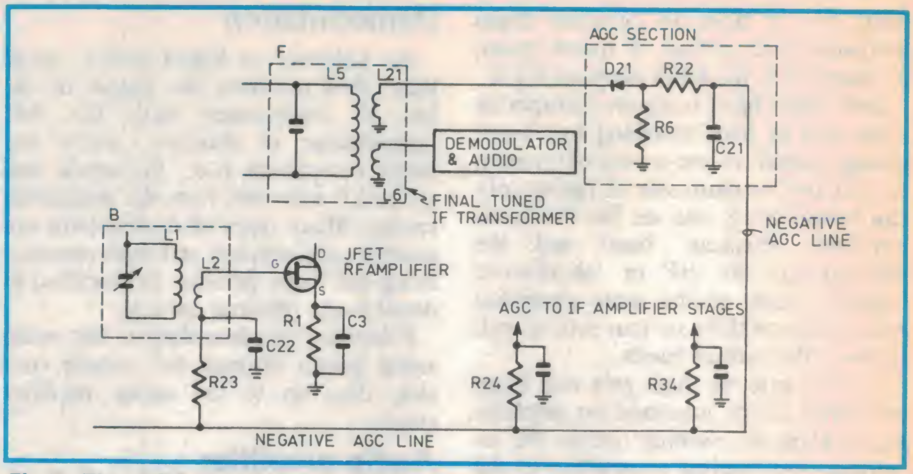


Fig.7: The AGC circuitry of a typical superhet receiver using semiconductor devices.

constant (i.e., the RC product R22.C21) is usually made longer than 30 milliseconds.

The output from the filter R22/C21 is a smoothed negative DC voltage, called the AGC line voltage, directly proportional to the average amplitude of the RF signal strength. We will now use this negative DC voltage to control the gain of all the IF amplifiers in the receiver, and perhaps the RF stage (if one is present).

The idea is that the stronger the RF signal, the greater the negative AVC line voltage, which we will use to reduce the gain of the intermediate amplifier stages and RF stage on strong signals. Then vice-versa on weak signals, the AGC line DC voltage will be less, allowing the gain of those stages to rise.

By this automatic control we hope to achieve constant amplitude output, even if the received signal strength varies.

Fig.7 shows the AGC rectifier and filter D21, R22, C21 and the AGC line going to RF and IF stages. Some detail is shown of the RF stage and its AGC connections. Similar AGC connections are made to all IF stages, but note that the mixer stage is not usually AGC controlled.

The gate of the RF amplifier JFET transistor is fed by radio frequency signals from L2, and also fed a negative DC potential from the AGC line via L2. The small capacitor C22 bypasses all RF signals at the low side of L2 to ground, to prevent RF signals flowing in the AGC line.

Resistor R23 together with C22 form a little decoupling filter, and there is a similar filter in each other controlled IF amplifier. These isolate the high frequency signals of each IF and RF amplifier. Such high frequency isolation is essential, preventing any RF or IF cross-coupling between stages via the AGC line (which could lead to high frequency instability).

Superhet bandwidth

The passband of the overall superheterodyne receiver is essentially the passband of the intermediate amplifier section, even if an RF stage is used. This is because the IF transformers can be designed and manufactured to have higher Q value than is possible for the variable frequency tuned circuits of the RF and mixer stages.

Also IF transformers for radio receivers are designed to have 'loose-coupled' tuned primaries and secondaries (i.e., the coupling factor is below critical coupling).

Because of these two characteristics of IF transformers, the IF stages can be more sharply tuned than any variable-tuned RF stages.

The use of many IF stages narrows the bandwidth still further, and while this is desirable for separating stations, the bandwidth may be too narrow to receive all the high notes and high harmonics in the broadcast music.

Superhet versus TRF

Therefore a few hi-fi enthusiasts still prefer TRF receivers with their broader tuning, for reception of high quality local broadcasts. Although popular some years ago, this preference for TRF has faded today as better results can be had receiving hi-fi music from the FM stations. FM receivers will be discussed in a later episode.

While the TRF receiver is only useful for short-to-medium distance reception, for long distance reception the superheterodyne type receiver is essential as only superhets can achieve sufficient sensitivity and narrow selectivity.

The superhet receivers outlined in this

(Continued on page 137)

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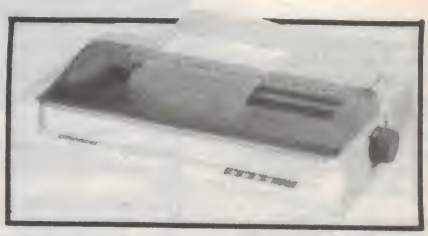

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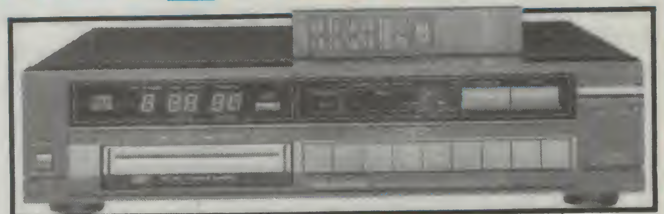

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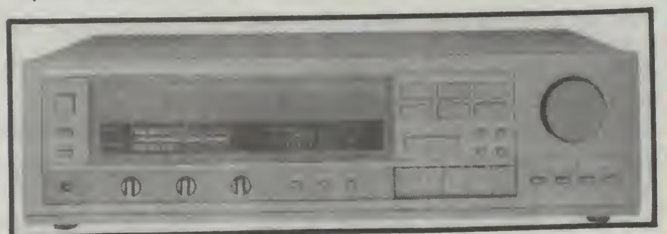

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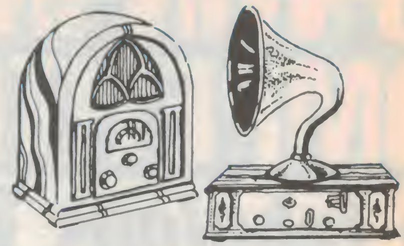


Cabinet restoration

It may surprise the new vintage radio enthusiast to learn that one of the most controversial topics for serious collectors is the question of cabinet restoration. One faction says that a radio should be displayed as found, with dents, scratches, warts and all. Others contend that a receiver is only fit to be seen when it looks at least as pristine as it did when it left the factory.

In Britain and the United States, restoration has been the subject of some strong words from respected authorities, and the N.Z. Vintage Radio Society members conducted a prolonged debate some years ago, with no final resolution. What then is all the fuss about?

The key issue is originality. The purists insist that an artifact should not be modified in any way, or have incorporated any materials that were not available at the time of its construction. The opposite school maintains that many valuable relics are unsatisfactory in their 'as found' condition and accepts that modern coponents and materials may have to be used, but concedes that every attempt should be made to conform to the original concepts and intentions of the designer.

Absolute originality can be an unrealistic ideal, as there are few radios that have not been serviced of worked on at some time.

An extreme example of the restoration school is the vintage car movement. By the very nature of their purpose and treatment, old cars are rarely, if ever, found in good original condition and collecting is practically synonymous with complete rebuilding and refinishing. Some examples have so much care lavished on them that the finish of the paintwork and chrome is considerably better than the manufacturer would have intended or could have afforded. Prizes are awarded at shows for perfection of paintwork and appearance.

Many museum curators do not approve of this approach at all. They contend that perfection of finish is secondary to authenticity and anyway, all materials deteriorate in time and it is unrealistic to pretend otherwise.

In the art world, classic works are being painstakingly 'derestored' in an attempt to undo the mistakes of past misdirected enthusiasms. Radio collecting has found its place somewhere in between the over-restoration and the purist disciplines.

A compromise

The most practical approach for collectors to adopt is a compromise between these extremes. Eliott Sivowitch, Radio Curator of the Smithsonian Institution, told me that their approach is, if at all possible, to tidy up an exhibit using cleaning agents and polishes. Only if these fail will refinishing work be considered.

It seems to me that what the Smithsonian judges to be correct should be a good guide for amateur collectors. It is sometimes surprising what a bit of elbow grease and a domestic cleaner will achieve. Preparations are available for the rejuvenation of tired and crazed lacquer.

Significantly, at an auction, reasonably sound receivers in original condition will invariably realise more than even well restored models. In other words, refinishing is likely to devalue a collectors item, so unless you really are an expert, leave old and rare cabinets alone until you have had a lot of experience!

Consideration should be given to employment of a professional refinisher if a valuable cabinet is in a bad way.

When to refurbish

Despite all this there are times when refinishing a cabinet is appropriate.

Radios from around 1940 and later are not rare or particularly valuable. Still capable of doing a good day's work, they are entirely suitable as everyday domestic receivers, and definitely have a place in collections. Wooden cabinets of this era were pieces of attractive furniture with classic veneers and really come to life when properly polished. Many are still in excellent condition and a good clean and an application of furniture polish is all that is necessary for rejuvenation.

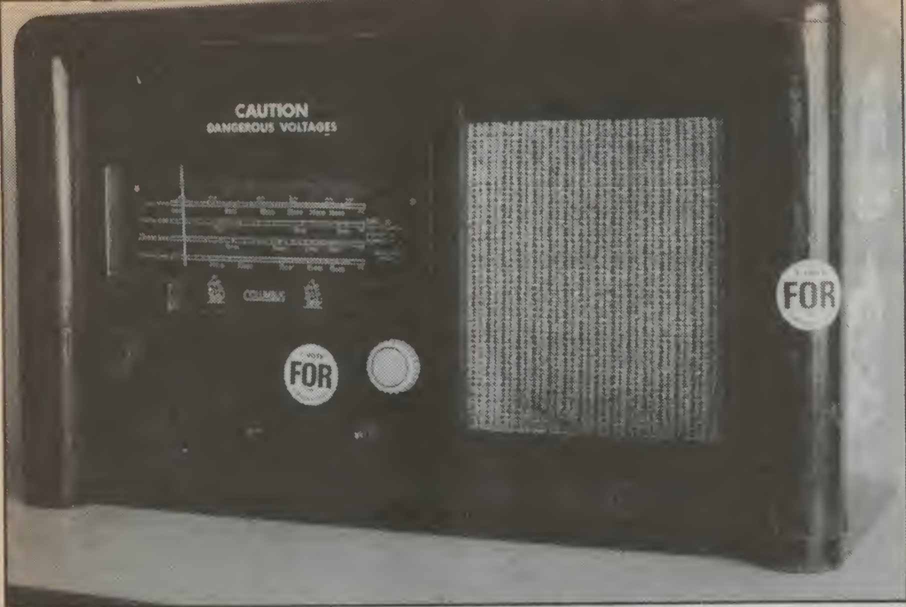
Some cabinets have not been so fortunate. Many fine receivers became unfashionable and were relegated to the workshop, garage or factory, to spend their time belting out the top 40 tunes or sporting commentaries. Knobs were often lost, or were adjusted with greasy or paint covered fingers. The cabinets were knocked about and became prime targets for pinups and stick-on decals and as repositories for glasses, cans and cups.

The result of all this rough treatment is a finish that is generally beyond saving. It is at this stage that these old classics can often be obtained for the asking.

Such a receiver came my way recently. Saved from the rubbish collector, it had suffered from the usual treatment handed out to workshop hacks. Knobs were missing and one was replaced with an obviously incorrect type. Labels and dirt hid the inlaid veneer. After the treatment I am about to describe, it now looks like new and graces the Lankshear conservatory.

The set in question is a New Zealand made Columbus 90, typical of literally scores of models of the 1940's from both sides of the Tasman.

I am not, in this article, dealing with servicing of the chassis. This is a very extensive subject which I hope to cover in later articles. For now, assuming that



The author's Columbus 90 mantel model, before cabinet restoration. It dates from the 1940's. Note the scratched lacquer and stickers plastered over the cabinet.

the radio is working, I suggest that all paper and electrolytic capacitors as well as resistors should be checked with a meter. Replacements are inexpensive and any suspicious characters should be renewed.

A big job

Refinishing an old receiver cabinet is not a project that can be completed in one evening. If you are going to restore the finish on a wooden cabinet, there are no half measures.

Be prepared to strip the cabinet down completely to the wood. Under no circumstances should the original polish be covered over with new lacquer. This is referred to by a fellow collector as the 'toffee apple treatment', and looks terrible.

First remove the knobs and chassis bolts, to take out the chassis. In larger radios the speaker will be separate and fastened to the cabinet by wood screws. At this stage a thorough dusting with a paint brush and vacuum cleaner is a good idea. Put the chassis and speaker to one side, along with the hardware and make a thorough inspection of the cabinet to dismantle it as much as possible.

At the least remove the speaker mounting board, grill and dial escutcheon. The grill cloth will be either glued to the cabinet or the speaker board. Either way it is likely to be the worse for wear, dirty and faded and unless laundering is successful, it is best discarded.

Removing the finish

The success of the whole project depends on the thoroughness of the removal of the old finish and subsequent preparation of the wood for refinishing. Sanding, scraping and stripping are the recognised methods and each has its merits and traps.

Hand sanding is safest, but slowest. Always use a cork sanding block and medium grade sandpaper. Do not be tempted to use a coarse paper to speed up the work. The result will be deep scratches in the wood, which will be very hard to remove. An orbital power sander is much more efficient, but unless great care is taken, thin veneer will be cut through with disasterous consequences. A steel scraper can be very effective, but requires skill to sharpen properly and use without damaging the cabinet.

The easiest method, but the most expensive, is to use a proprietary paint stripper. These are pungent smelling pastes that are applied thickly and left to soften the finish. After the stripper has been left to work, for half an hour or so, the resulting goo is removed with a scraper, hopefully leaving bare wood underneath. Incomplete removal can be corrected by a second coat.

A mixture of remover and old lacquer is inflammable, so dispose of it carefully. The active ingredient of stripper is actually a gas, the paste being only the vehicle to carry it. It is, therefore, a good idea to conserve the gas by covering the cabinet with a plastic sheet or better still, putting it in a large plastic bag. Always use rubber gloves or there will be more than paint removed!

When stripping is complete, the whole cabinet should be scrubbed with a stiff brush and water. This may seem a bit drastic, but it does no harm, makes final sanding much easier and gets rid of the last vestiges of paste.

Repairing damage

Regardless of the method used, we have now reached the stage of attending to the woodwork. Lifting veneer can be held in position with masking tape and reglued with PVA glue.

Dents can often be removed by wetting the depressed area, then covering it with a wet rag and heating with a household iron. The resulting steam swells the pores of the wood and forces the fibres back into shape.

Chips, borer holes and small cracks in the veneer can often be disguised with plastic wood. Be careful to match the colours, as bare wood can be considerably paler than when finished. An extreme case is walnut. Unfinished, it is a light brown, but when wetted, even with water, the colour can be almost black.

If there is any suspicion of borer infestation, obtain one of the liquid poisons sold for the purpose. A typical compound is diluted with mineral turpentine and painted liberally on the interior of the cabinet.

When the blemishes are removed, sand the cabinet down using a sanding block, and fine aluminium oxide or garnet paper, rubbing only with (i.e., along) the grain. Be particularly careful to get the last vestiges of old lacquer out of the mouldings and grooves.

It is likely that some solid parts of the cabinet will be made from inexpensive wood, stained with dyes to resemble fine timber. Lacquer removal, washing and sanding between them will have removed most of this colouring. Oil stains are rubbed into the wood, but tend to hide the grain and are best used on open pored timbers. Water based stains are the most stable but raise the grain, which has to be resanded.

Non grain raising (NGR) stains are the easiest to apply. They are available in many shades at paint and handyman stores. Being spirit based, they dry instantly and should be applied with a small paint brush.

Stains are concentrated dyes and their effect can be very easily overdone. Be careful because unwanted splashes are very hard to remove. Generally, figured woods and veneers are best left unstained. The insides of many cabinets were stained and should be redone if at all patchy.

It will be obvious from all this, that restoration can be fairly time consuming. There is plenty to go on with and next month I will describe the relacquering and reassembly work.

Solid State Update

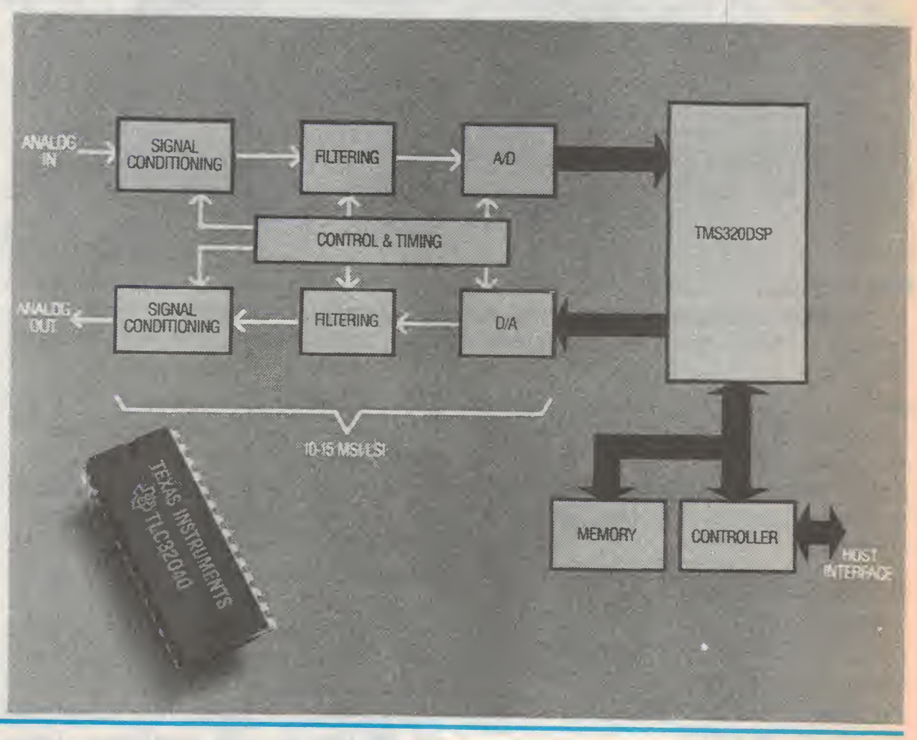
KEEPING YOU INFORMED ON THE LATEST DEVELOPMENTS IN SEMICONDUCTOR TECHNOLOGY

'Universal' DSP peripheral

Texas Instruments has announced the availability of a single chip interface that greatly reduces the need for analog design expertise in the development of digital-signal-processing (DSP) systems. A universal DSP peripheral, the new analog-interface circuit (AIC) chip is a complete, flexible, high-performance analog-to-digital input/output system.

The TLC32040 integrates the functions of 10-15 MSI and LSI functions, including an anti-aliasing input filter, analog-to-digital and digital-to-analog converters with 14 bits of resolution and 10 bits of linearity, a low-pass output-reconstruction filter, signal-conditioning blocks, a multiplexer, timing and control logic and a four-mode serial interface. The AIC chip's filter characteristics, sampling rates, gain selection and phase adjustment are software-programmable.

For further information contact Texas Instruments, 6-10 Talavera Road, North Ryde 2113, phone (02) 887 1122.



Data transmission IC

The Philips SAA1045 universal driver/detector integrated circuit transmits data directly across twisted-pair lines up to 150m long. This is the farthest distance covered by a currently available circuit as most existing drivers are limited to a few metres.

As well as connecting directly to the D2B (digital data bus), the CMOS SAA1045 can implement bus protocols with data rates up to about 1Mbit/s. The circuit is in an 8-pin DIL or SO package, yet contains detector, driver, digital filter and analog circuits.

The SAA1045 suits office, home and factory applications. It can be used to connect up all the electronics circuits in a car. The bus provides for a response time within 2ms, and the twisted-pair wire format makes it inexpensive to implement. The D2B is designed to connect home entertainment systems and also works as the cluster bus on the Japanese HEB (home electronic bus).

For further information please contact Philips Elcoma, 11 Waltham Street, Artarmon 2064, phone (02) 439 3322.

PAL devices

Advanced Micro Devices and SEEQ Technology recently announced the first in a family of jointly developed Programmable Array Logic (PAL) integrated circuits that promised to expand the fast-growing programmable logic market. PAL devices have evolved to meet the increasing demand for logic devices in virtually all computation and communication systems, offering a low-cost, high performance alternative to expensive custom solutions.

The new products, developed with a unique, electrically erasable (EE) CMOS process, can be quickly and easily programmed, erased, and reprogrammed by customers to meet specific requirements not available in standard parts.

The new devices are ideal for applications that demand easy programmability and low power consumption, such as lap-top computers, instruments, medical data-logging systems, telephone line cards and on-line transaction processors. These devices replace as many as seven standard logic parts, reducing system component count and economizing on board space.

For further information contact RAE Industrial Electronics, Melbourne, phone (03) 277 4033

Stellar sensor

The most advanced CCD image sensor yet developed for scientific and astronomical research is said to have been delivered to the Lick Observatory. The 400 x 1200 pixel CCD was developed by EG & G Reticon in Sunnyvale, California.

The large 400 x 1200 format gives astronomers more resolution than has heretofore been available. The device has demonstrated a dynamic range of 140,000 to 1 at a temperature of 120K. These features allow the Lick astronomers to study and analyse faint and more distant light sources in space. CCD arrays provide greater sensitivity than is possible with photographic plates.

For more information contact Email Electronics, 15-17 Hume Street, Huntingdale 3166, phone (03) 544 8244.

1 Meg DRAM

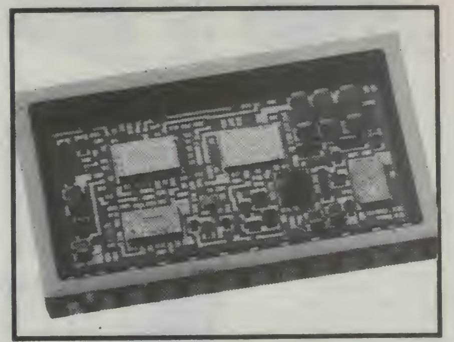
Texas Instruments has become the first major US supplier of one-megabit dynamic random access memories (DRAMs) for military applications. Now in production, the Class B-processed DRAM is organised as 1,048,576 bits x 1-bit. TI is also characterising a one-megabit DRAM with a 262,144 x 4-bit organisation for military applications.

Designers who use one-megabit DRAMs to replace 256K devices can reduce board space and system cost or provide four times the memory in the same area. One-megabit devices are most appropriately used in military applications that require large, dense memory storage. These include graphics, cockpit displays, image processing, speech recognition and mainframe computers.

The SMJ4C1024 (x1) and the SMJ44C256 (x4) are fabricated in TI's EPICTM (Enhanced Performace Implanted CMOS) technology, and are characterised over the full military temperature range (-55 to 125° Celsius). Previous DRAM generations typically have been fabricated in NMOS technology which limited their high-temperature operation to 110° Celsius.

For further information contact the Semiconductor Division, Texas Instruments, 6-10 Talavera Road, North Ryde 2113, phone (02) 887 1122.

12 bit 500kHz ADC



DATEL has introduced the ADS-111 sampling A/D converter. Unmatched in size, the ADS-111 utilizes an innovative hybrid design that combines a high speed 12-bit A/D converter and a fast sample and hold amplifier in a space-saving 24-pin DIP. The ADS-111 digitises sinusoidal input signals at minimum rates of 500 thousand samples per second with 12-bit binary performance.

By combining both the A/D and S/H in one device, critical layout factors are achieved to ensure stable, high-bandwidth operation. The A/D converter uses a subranging, or two-pass, technique for the conversion process to provide high speed and precision results. The S/H has a very fast signal acquisition time to help achieve the 500kHz minimum throughout rate.

The ADS-111 has a pin-programmable feature that allows analog input signals of either 0 to +10 volts to be chosen as the input. The digital inputs and the three-state outputs are TTL and CMOS compatible.

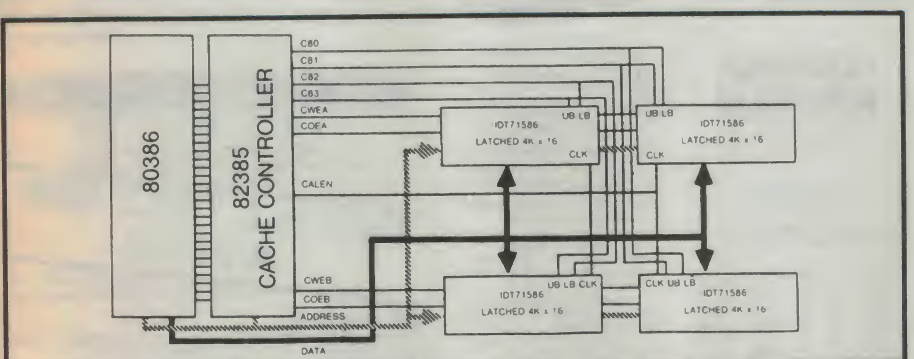
The standard version, coded ADS-111MC costs $395.00.

For further information contact Elmeasco, 12 Maroondah Highway, Ringwood 3134, phone (03) 879 2322.

VLSI chip set in PS/2

The IBM PS/2 Model 35 will be AT compatible, thanks to the VL82CPCAT chip set from VLSI Design. IBM have chosen the VLSI ICs for this new machine, the latest in the PS/2 line-up.

For further information contact Energy Control International, 26 Boron Street, Sumner Park 4074, phone (04) 85 8742.



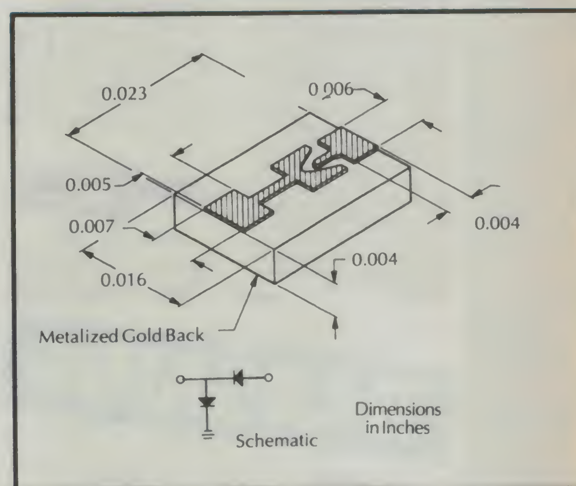
SRAM for 80386 systems

Integrated Device Technology recently introduced a 4K x 16 static RAM (SRAM) optimized to work with Intel's 82385 cache controller in 80386 systems. This cache SRAM, the IDT 71586, features a 35ns access time with an on-chip address latch.

The IDT 71586's on-chip address latch improves speed by reducing interchip delays and eliminating the need for external glue logic. At the same time, board space is reduced by as much as 57%.

In an Intel 80386-based system using an 82385 cache controller, four IDT 71586 SRAMs replace 27 memory and logic chips and use only 1/3 of the power to perform the equivalent function.

For further information contact George Brown Marketing Group, 456 Spencer Street, West Melbourne 3003, phone (03) 329 7500.



Microwave PIN switch

Benmar has introduced the SSE3792 single silicon chip containing two PIN type junctions in a monolithic series-shunt configuration. This easy pad bonding, rugged design is for use in compound multi-throw switch designs up to 26GHz.

This new Alpha Semiconductor Division item features excellent resistance-capacitance characteristics, low parasitic inductance, rugged monolithic construction, and thus replaces the need to combine discrete beam-lead and chip diode devices. The simpler assembly allows higher production yields and increases switch MTBF (mean time between failures).

For information contact Benmar, Level 67, MLC Centre, Sydney, phone (02) 233 7566.

CAR ALARM SYSTEM WITH REMOTE CONTROL AND PAGER

- Complete automotive protection system with back-up battery protected siren
- Supplied with remote key switch, pager and glass breakage detector
- 110dB siren with independent inbuilt rechargeable back-up battery
- Automatically arms when ignition is switched off
- Will not start 30 second exit delay until last door is closed

SELECTABLE OPTIONS
- Transmits signal to pager only, siren only or to both
- Gives audible beep when the system is armed or disarmed
- Valet mode: disarms the system completely for service, etc.
- Extends car power antenna when triggered for long range paging
- Pressing both remote key buttons together activates panic alarm

OUTPUT TERMINALS
- 8 ohm siren/speaker outputs
- Normally open and normally closed output terminals
- 12V DC 300mA output for other alarm devices

COMPONENT BREAK DOWN
Main Unit: Controls and monitors the complete alarm system. All input and output cables are connected to this
Pager: Portable monitoring receiver "beeps" when the alarm is activated up to 2 miles away. Can also be used as a pager when "paging" button is pressed on the main control unit.
LED Indicator: Shows what stage the alarm system is in.
ie: armed/disarmed and exit/entry period. It also has a memory LED that indicates that the system has been triggered and has automatically reset.
Remote Arm/Disarm Key: This transmitter allows you to activate or deactivate the car from outside the vehicle. It also has a panic feature that triggers the alarm when both buttons are depressed together.
Glass Breaking Sensor: This is a piezo sensor that is activated by the frequency of breaking glass which helps to prevent false alarms.
Back-up battery: Rechargeable back-up battery system which stops unauthorised disconnection of the siren. If any of the wires going to the siren are cut it will sound. It also has a keyed manual over ride switch for disarming or servicing.
S15056 .... **$399**

HORWOOD ALUMINIUM CASES

H10382 3 x 4 x 2 inches	$ 5.50
H10383 3 x 4 x 3 inches	$ 6.50
H10384 3 x 4 x 4 inches	$ 7.50
H10385 3 x 4 x 5 inches	$ 7.95
H10386 3 x 4 x 6 inches	$ 8.50
H10387 3 x 4 x 7 inches	$ 9.50
H10388 3 x 4 x 8 inches	$10.50
H10389 3 x 4 x 9 inches	$10.95
H10390 3 x 4 x 10 inches	$11.95

OMNI-DIRECTIONAL WIRELESS MICROPHONE

Tuneable: 92 - 104MHz
Freq. Response: 50 - 15kHz
Range: Over 300 feet in open field
Modulation: FM
Power Source: 9V Battery
Type: Electret Condenser
Dimensions: 185 x 27 x 38mm
Weight: 160 grams
Cat. A10450 .... **$19.95**

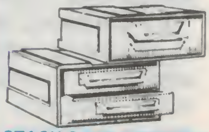
CD TO CAR CASSETTE STEREO ADAPTOR

Enables a portable CD player or portable TV to be played through any car speaker system by using the cars cassette player. Reduces the risk of theft. Just plug in when required, and remove when you are finished. Hard wiring not needed.
A10011 .... **$29.95**

NOW OPEN IN SYDNEY!

74 PARRAMATTA RD, STANMORE
PHONE (02) 519 3134

MERRY CHRISTMAS



STACK COMPARTMENTS

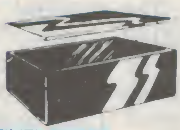
- Precision dovetail system allows units to be interlocked together
- Large handle with index card slot
- One piece moulding ensures trays will not jam or sieze
- Size: 110(W) x 120(D) x 55(H)mm

H10080 Single tray.. **$3.95**
H10081 Double tray.. **$4.25**

SERIES 5000

INDIVIDUAL COMPONENTS TO MAKE UP A SUPERB HIFI SYSTEM!

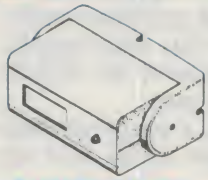
By directly importing and a more technically orientated organisation, ROD IRVING ELECTRONICS can bring you these products at lower prices than their competitors. Enjoy the many other advantages of RIE Series 5000 kits such as "Superb Finish" front panels at no extra cost, top quality components supplied throughout. Over 1,500 sold!



UTILITY BOXES

Plastic boxes with aluminium tops, and available in four sizes. Very popular for projects and very economical!

H10101 150x90x50mm	$ 3.25
H10102 195x113x60mm	$ 4.50
H10103 130x68x41mm	$ 2.75
H10105 83x54x28mm	$ 1.95
H10110 120x65x38mm	$ 2.95
H10112 120x65x38mm (Metal top)	$ 2.95



PASSIVE INFRA RED DETECTOR

Compact P.I.R. with adjustable corner or wall mounting bracket, dual pyroelectric infra red sensing element gives a coverage 2 x 14 zones 2m high and 10m wide.
- Sensitivity adjustment control
- Detecting range 12-15 metres at 90 degrees
- Detecting zones 9 long (up), 5 short (down)
- LED indicator for walk test. (can be disabled)
- Shielded against RF interference
- Relay output NC or NO at 30V (AC-DC) 0.5A max.
- Integral NC tamper switch
- Operating voltage 10.5 - 16V DC
- Current 20mA with LED 25mA

Cat. S15075 .... **$145**

"SNAP TOGETHER" PLASTIC CASE

Top and bottom simply snap together (no screws required), removable front and back panels.
Size: 186(W) x 125(D) x 50(H)mm
Cat. H10116 .... **$7.95**

POWER AMPLIFIER

WHY YOU SHOULD BUY A "ROD IRVING ELECTRONICS" SERIES 5000 POWER AMPLIFIER
- 1% Metal Film resistors

SPECIAL, ONLY $399 SAVE $50

... developed by ... ELECTRONICS and is being supplied to other kit suppliers.

SPECIFICATIONS: 150 W RMS into 4 ohms (per channel)
POWER AMPLIFIER: 100W RMS into 8 ohms (+ −55V Supply)
FREQUENCY RESPONSE: 8Hz to 20Hz +0 −0.4 dB 2.8Hz to 65KHz, +0=3 dB. NOTE: These figures are determined solely by passive filters.
INPUT SENSITIVITY: 1 V RMS for 100W ouput.
HUM: 100 dB below full output (flat).
NOISE: 116 dB below full output (flat, 20KHz bandwidth)
2nd HARMONIC DISTORTION: ‹0.001% at 1 KHz (0.0007% on Prototypes) at 100W ouput using a + =56V SUPPLY rated at 4A continues ‹0.0003% for all frequencies less than 10KHz and all powers below clipping.
TOTAL HARMONIC DISTORTION: Determined by 2nd Harmonic Distortion (see above).
INTERMODULATION DISTORTION: 0.003% at 100W (50Hz and 7KHz mixed 4:1).
STABILITY: Unconditional
Cat. K44771 .... **$449**
Assembled and tested $599
packing and post $10

KEY SWITCHES

Cat. S12500 1-9 10+ Normally $7.95
1-9 10+ 25+
$4.95ea $4.25ea $3.95ea

SAVE $150 COMPLETE KIT $649

VIFA/AEM 2 WAY SPEAKER KIT!

This exciting new speaker kit, designed by David Tilbrook (a name synonymous with brilliant design and performance) uses VIFA's high perfomance drivers from Denmark. You will save around $800 when you hear what you get from this system when compared to something you buy off the shelf with similar characteristics. Call in personally and compare for yourself!

The system comprises...
2 x P21 Polycone 8" woofers
2 x D25T Ferrofluid cooled dome tweeters with Polymer diaphrams
2 pre-built quality crossovers

The cabinet kit consists of 2 knock-down boxes in beautiful black grain look with silver baffles, speaker cloth, innerbond, grill clips, speaker terminals, screws and ports.

D25T SPEAKER SPECIFICATIONS
Nominal Impedance: 6 ohms
Frequency Range: 2 - 24kHz
Free Air Resonance: 1500Hz
Operating Power: 3.2 watts
Sensitivity (1W at 1m): 90dB
Nominal Power: 90 Watts
Voice Coil Diameter: 25mm
Air Gap Height: 2mm
Voice Coil Resistance: 4.7ohms
Moving Mass: 0.3 grams
Weight: 0.53kg

P21 WOOFER SPECIFICATIONS:
Nominal Impedance: 8 ohms
Frequency Range: 26 - 4,000Hz
Free Air Resonance: 33Hz
Operating Power: 2.5 watts
Sensitivity (1W at 1m): 92dB
Nominal Power: 60 Watts
Voice Coil Diameter: 40mm
Voice Coil Resistance: 5.8ohms
Moving Mass: 20 grams
Thiele/Small Parameters: Qm: 2.4, Qe: 0.41, Qt: 0.35, Vas: 80.1
Weight: 1.65kg

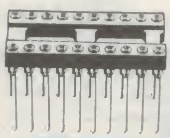
Complete Kit Cat.K16020 ... **$799**
Speaker Kit Cat.K16021 ... **$649**
Cabinet Kit Cat.K16022 ... **$209**

MODEM TRANSFORMER

PCB pins, spacing 25mm, equipment to line, 15mm between equipment pins, 25mm between line pins

CAT.No.	1-9	10+
M10230	$14.95	$13.95

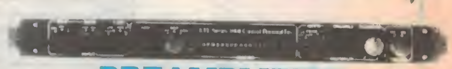
BARGAINS



WIRE WRAP IC SOCKETS

These quality 3 level wire wrap sockets are tin-plated phosphor bronze.

Cat.No.	Description		1-9	10+
P10579	8	pin	$1.50	$1.40
P10580	14	pin	$1.85	$1.70
P10585	16	pin	$1.95	$1.80
P10587	18	pin	$1.95	$1.80
P10590	20	pin	$2.95	$2.70
P10592	22	pin	$2.95	$2.70
P10594	24	pin	$3.95	$3.50
P10596	28	pin	$3.95	$3.50
P10598	40	pin	$4.95	$4.50



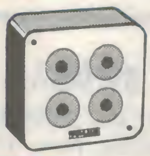
PREAMPLIFIER

THE ADVANTAGES OF BUYING A "ROD IRVING ELECTRONICS" SERIES 5000 PREAMPLIFIER
- 1% Metal Film ...

SPECIAL, ONLY $359 SAVE $40

... believe that dollar for ... commercial unit available that sounds as ...

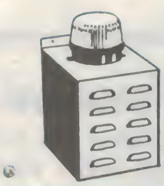
SPECIFICATIONS:
FREQUENCY RESPONSE: High-level input: 15Hz = 130KHz, +0. = 1dB
Low-Level input-conforms to RIAA equalisation + = 0.2dB
DISTORTION: 1KHz ‹0.003% on all inputs (limit of resolution on measuring equipment due to noise limitation).
S/N NOISE: High-Level input, master full, with respect to 300mV input signal at full output (1.2V) ›92dB flat ›100dB A-weighted, MM input, master full, with respect to full output (1.2V) at 5 mV input 50ohms source resistance connected ›86dB flat/92dB A-weighted MC input, master full, with respect to full output (1.2V) and 200uV input signal: ›71dB flat ›75dB A-weighted.
Cat. K44791 .... **$399**
Assembled and tested $699
packing and postage $10



PIEZO SIREN

- 4 piezo units in a high impact plastic cabinet
- Input 12V DC - 200mA
- Output 115dB at 1m, dual tone
- Compact size 105 x 85 x 45mm
- Smart design suits interior use

Cat. S15071 .... **$24.95**



EXTERNAL SIREN & FLASHING LIGHT

Housed in a waterproof, metal case, with tamper switch.
SPECIFICATIONS:
Siren:
DC 12V, 450 mA
Impedance 8 ohm
S.P.L. (dB/W) 110
Dimensions: 135 x 150mm
Flashing Light:
DC 12V
100 flashes per minute
Dimensions: 82 x 100mm
.... **$89.50**

BIG MOUTH CAR ALARM

FEATURES.....
- Easy installation
- Automatic on/off
- Loud alarm signal
- Auto reset
- Low Price!

SPECIFICATIONS:
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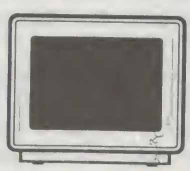

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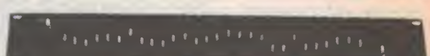

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Stroboscopic Tuner

Would you please advise me of a source of supply for the MO83 IC used in the July 88 Stroboscopic Tuner project. (R.V., Taroona, Tas).

• ***This component is available through SGS Components who are represented in Australia by Promark Electronics (6-8 Clarke Street, Crows Nest 2065).***

EPROM Programmer

I am writing in regard to the 1986 upgrade of the 1980 Eprom Programmer project. Would you please advise if the full software listings are still available for this project.

• ***Software listings suitable for the TRS-80 model 1 and the Sorcerer computers are still available for this program. Photocopies of the two original articles are available for $4.50 each. When ordering these articles, it would help if you quote the file number for the listing you require, as the project was presented in two parts. The file number for the TRS-80 version, July 1980 is 2/CC/51, for the Sorcerer version, August 1980, the file number is 2/CC/52.***

Light frequencies

I am wondering if you could advise me of the frequencies (in hertz, please) of the various colours of the light spectrum. (D.B. Darwin NT)

• ***We don't normally use these columns to answer general technical questions, but as you have asked so nicely, and because many readers may like to know these frequencies, we are glad to oblige. Our reference source is Colour Television Theory by Hutson, 1971, McGraw Hill, although we have had to convert the wavelengths given to frequency values.***

Red has a wavelength of 780nm, which equates to 384.6 million million hertz or 384.6 terahertz. Green, which is approximately mid way in the spectrum comes out at 500nm, or 600 terahertz. Finally, at the top end, violet has a wavelength of 380nm, giving a frequency of 789 terahertz.

To convert wavelength to frequency, divide 300,000 by the wavelength in nanometres and call the answer terahertz. This is based on the premise that a wavelength of 1 metre has a frequency of 300MHz. So there you have it!

Electric Fence

I am concerned about the Electric Fence project described in EA, October 86. There are two problems we have found with all of the kits that we have sold or built. Invariably the case is 'live', and after a short period of operation, the two BUZ71 FETs explode rather violently, taking all the associated ICs and other components.

We urge you to give this your prompt attention, as this kit appears to be a safety hazard.(Nathan Ross Electronics, Tenterfield, NSW)

• ***We sure have had our problems with this project. An extensive errata was published in EA February 1987, and other reader enquiries have been answered in these columns in May 87. Your letter is not the only one in our files, and we can only refer all enquiries to our previous answers.***

Battery charging

I am relatively inexperienced in the field of electronics, but have built various kits over the years. My questions concern charging batteries using a benchtop power supply. For example, can I charge ten, series connected, size AA NiCad batteries from a variable power supply? Can I charge NiCads at all from a variable power supply? Also, can I trickle charge a lead-acid battery from a variable power supply. (G.W. Karratha, WA)

• ***There is no reason why a fully adjustable power supply cannot be used as a NiCad battery charger, providing you set the power supply correctly. For example, the current limit setting of the power supply – assuming it has one – should be set to equal the recommended charge current of the battery.***

If you are after a fast charge rate, be careful to turn the supply off after the ampere-hours time has expired. Put simply, this means that if you double the charge rate, halve the charge time. However, be very careful that the batteries do not overheat, as they can explode due to internal heating if subjected to an excessive charge current.

If the charger does not have a current limit adjustment, set the output voltage to the value the batteries will finally charge to. For trickle charging, it is sometimes useful to connect a series resistor between the charger and the batteries to ensure the recommended charge current is not grossly exceeded during the initial charging.

If all this seems a bit complicated, then the process can be automated using a deep-cycle charger, as described in our March 87 issue.

It is also quite possible to trickle charge a lead acid battery using a variable power supply. The main point to watch is that the charging voltage from the power supply is set to no more than around 14V. Also, watch that the charge current does not cause excessive gassing of the battery, although most bench top supplies are only good for 2 amps anyway. Naturally, allow plenty of ventilation around the battery during charging.

FM tuner

I have recently constructed the "El Cheapo" FM stereo tuner (EA April 88) and I am very pleased with the quality of the sound. However, there is noticeable hum at normal listening volume, even though the RC filter is included in the power input from the DC plug pack.

Also, can you advise me whether EA has ever done a project that can supply a stabilised 50Hz, 240V power source for a turntable. My understanding is that such a device can provide a stable supply regardless of mains frequency or voltage variations. (J.N. Como, WA)

• ***The hum you are hearing is most likely due to an excessive ripple content from the DC plug pack. The RC filter was included in the original design to remove the remaining mains***

ripple from an average plug pack – it seems yours has an excessive amount.

The solution may be to include another identical RC network in series with the one described, which will reduce the ripple by a further amount.

The best solution however, would be to include a series regulator device such as the three terminal regulator device type 7812. This would produce a ripple-free 12V supply from your 15V DC source, and should be inserted between the 2200uF capacitor and the remaining circuitry. Make sure the input voltage to the regulator is at least 15V DC.

An inverter designed to run a synchronous turntable was described in the August 85 issue of EA. Copies of this article are available from this office, and kits can be purchased from Altronics for $89.

Playmaster 60/60

I have had some problems with the Playmaster 60/60 amplifier, which I bought as a kit. Initially, the quiescent current taken by the left hand channel could not be reduced to its specified value – or even anywhere near it. However, I paid for the services of a technician, who was able to get everything going.

When it was returned, I felt that the amplifier was running rather hot, but the technician said this was normal. However, after a month, the unit failed completely. Upon removing the covers I discovered the PCB was badly discoloured due to heat, and lots of other heat associated problems had occurred. I have since tried to get the unit going with little success in the left channel – the right channel seems OK. (A.B. Glenalta, SA)

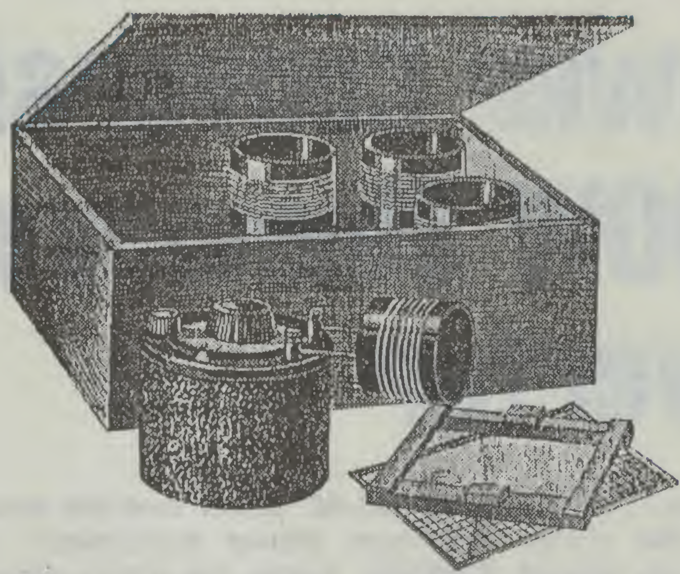
• *The problem with your amplifier appears to be largely due to thermal runaway, which has occurred in some versions of the kit. The May 87 issue of EA dealt with this and other difficulties, and included modifications and fault finding suggestions.*

The main change is the addition of an MJ340 transistor in place of the BC547 (Q12), which forms the 'Vbe multiplier' circuit. This improves the thermal tracking capabilities of the amplifier, and consequently its overall thermal stability.

The final destruction of one side of the power amp section is indeed unfortunate. The large voltage drop across the 560 ohm test resistors indicates a failure in one or both of the output transistors in that channel. These should be replaced, and the driver transistors carefully checked.

Finally, we advise that you refer to the points raised in the 'Feedback on the Playmaster 60/60' article presented in May 87, as these should be the solution to your problems.

What was it?



Back in the late 1920's, this item was regarded by radio enthusiasts as almost invaluable. The US company which made it later became well known and respected throughout the world as a maker of test equipment. *(Answer next month)*

November's Mystery Item:

Last month's historic puzzler was a low-speed induction motor for direct drive of gramophone turntables. It operated by inducing heavy eddy currents in an aluminium disc rotor, using the same principle used to drive the dials in today's kilowatt-hour electricity consumption meters.

This type of motor was quiet and smooth, and quite reliable due to the lack of idler wheels or belts. However speed regulation was quite poor and they were soon superseded by conventional induction motors with reduction drives. The cost in 1929 was 7 pounds 10 shillings.

Apology

We apologise to those who have written to us in recent times, but who are still awaiting a reply. We are only now returning to normal after a fire destroyed half our premises. Even so, we are still operating under great difficulties, due to destroyed files, reduced room and so on.

We value your letters, and sincerely regret the delays some of you are experiencing. Hopefully, we should soon be back to normal – please don't judge us too harshly.

NOTES & ERRATA

SONY KX-14CP1 VIDEO MONITOR: In the review of this product in the October 1988 issue, we said that it was compatible with an EGA graphics adaptor. This is not the case; in reviewing the unit we used a multi-mode video card, and apparently 'fooled' ourselves into thinking it was EGA compatible.

TV FIELD STRENGTH METER (August 1988): Zener diode ZD1 is drawn with reversed polarity on the circuit diagram, page 73. Resistor R15 should also be shown on the circuit as 5.6k, not 56k. Capacitor C9 should be shown connected to V1 (or SC), not SV. (File No. 6/TVT/7).

50MHz DIGITAL FREQUENCY METER (May 1988): Transistors Q4 to Q7 are shown on the PCB with collectors and emitters transposed, not collectors and bases as stated in November. (File: 7/F/34).

Product Review:

Power Conversions 300W Sinewave Inverter

There are plenty of utility DC-AC power inverters around at reasonable prices, but most deliver squarewave output. Here's an elegant Australian made unit which provides a clean sinewave output, with good efficiency.

Many people such as campers, boating enthusiasts, farmers and many others often have need for a source of mains power which is independent from the mains. In some applications, a portable generator can be used, but there are many instances where a generator is unsuitable for reasons of cost, noise, exhaust fumes or whatever. In these cases an inverter is a popular choice, producing the required 240V AC from 12 or 24V DC.

The most common criticism levelled against most electronic inverters is that their output is usually some form of square wave, not the sine wave that is obtained from normal general-purpose outlets. There are two main reasons for this. The first is that a squarewave inverter circuit is less complicated (and less expensive) than a similar capacity sinewave unit.

The other reason is that squarewave inverters are more efficient than their sinewave counterparts. This is because the output devices in the squarewave inverter are either on or off, thus minimising the power dissipation in these devices, and therefore increasing the efficiency. A sinewave inverter, on the other hand, has to turn its output devices on and off gradually, in order to generate the proper wave-shape at the output. This causes the output devices to dissipate (and hence waste) more power than those in a squarewave inverter.

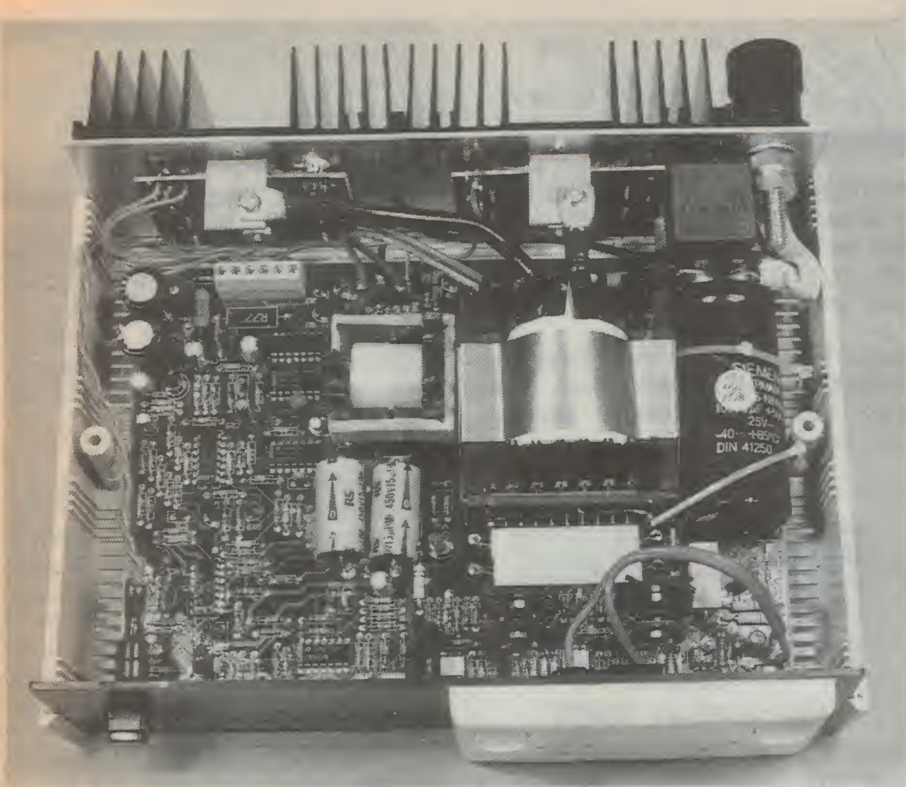
The problem with squarewave inverters is that the high harmonic content of the output can cause problems with the connected appliance. One prominent example is in powering audio or video equipment, where any harmonics of 50Hz passing through the power-supply can result in a very annoying buzz. The obvious way to circumvent this problem is to not present anything but the desired 50Hz to the power input of the appliance.

In answer to this problem, a company called Power Conversions in Frankston, Victoria, has released a medium power sinewave inverter. The device is rated at 250W continuous/300W peak, and is housed in a neat plastic instrument case, measuring 260mm wide, 80mm high and 230mm deep.

On the front panel is the main power switch, 5 status LEDs and a double general-purpose outlet. A green LED indicates when the inverter is is stand-by mode, while the other four are coloured red and indicate various error conditions.

The first of these relates to battery voltage. If the voltage of the battery drops below a pre-set level, the inverter will shut down, to prevent possible damage to the battery through being totally discharged. The inverter will also shut down if the temperature of its heatsink becomes too high, or if the load presented to its output is too reactive. In each of these cases, the appropriate LED illuminates to indicate the presence of the condition.

The final LED indicates that the out-



The inside story. The small ferrite-cored transformer behind the outlets is the reason for the unit's light weight.

put is overloaded. However the inverter does not immediately shut down in this instance, but merely imposes current-limiting on the output. This allows the unit to cope with the starting current of motors and incandescent lights, without shutting down immediately. However, severe overload conditions will shut the inverter down fully.

The rear panel accommodates the heatsinks for the output devices, and a pair of heavy-duty binding posts to which the battery leads are attached. The other ends of these leads carry a pair of colour-coded battery clips, to help ensure that the battery is connected up with the correct polarity.

Internally the unit appears to be solidly constructed, with all components excepting the output transistors mounted on a single printed-circuit board. The output transformer is quite small and light, and is also mounted on the PCB.

On the bench

We tested the inverter under a variety of load and supply conditions. The unit performed as expected with resistive loads, with good regulation (the output was 234V at full load), and distortion figures (less than 5%). Bear in mind that the mains coming from the ordinary power points in your home is usually distorted to the order of a couple of percent, depending upon the nature of the load on the system at the time.

The unit held no surprises when largely resistive loads were connected to its output. However, when inductive loads such as fluorescent lights or devices with large power transformers were connected, the unit would complain bitterly and in some cases shut down completely. Power Conversions recommend the use of power-factor compensated fluorescent lamps, which have a shunt capacitor across the line to bring the power factor of the load back towards unity. A similar approach could probably be used to accommodate other inductive loads.

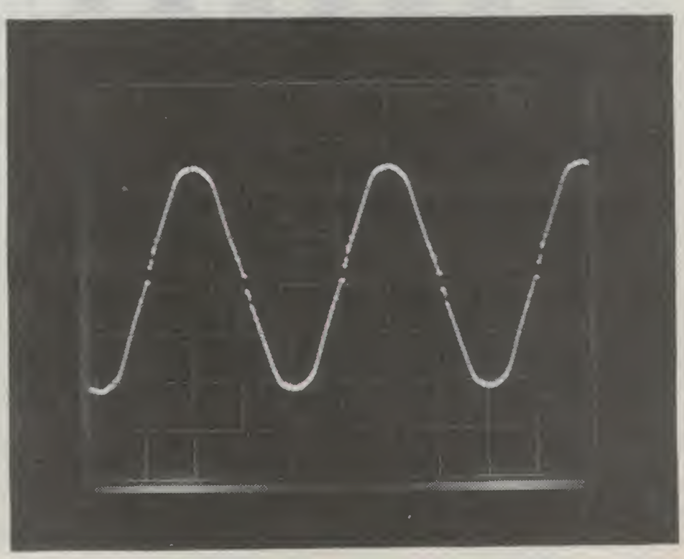
We found the maximum efficiency of the unit to be about 82% at 150W load, dropping to a little over 75% at full load. These figures are quite good for a sinewave inverter, and are not that much lower than many squarewave inverters. The review unit ran for over 30 minutes at full load before the thermal cut-out shut down the unit. As expected, the inverter also shut down when the battery voltage dropped below about 10.6V.

The inverter features an auto-start circuit, which allows the inverter to idle in its stand-by mode, until required. When a load is connected across the output, the inverter senses this, and immediately commences operation. In this stand-by state, the current consumption is less than 65mA, and the start-up is virtually instantaneous when a load is applied to the output.

Frequency stability was also more than adequate for most applications, varying less than 0.1Hz from no load to full, with about 0.2Hz drift on warm-up.

In summary then, the Power Conversions sinewave inverter proved itself to be a capable performer when running into resistive loads, and provided that suitable compensation measures are taken, can also handle inductive loads. For applications where an independent source of sinewave 240V AC is required without the problems associated with a generator, this unit is well worth a look.

The inverter is priced at $4.95 plus tax and is manufactured by Power Conversions Pty Ltd, 4 Chamouni Court, Frankston Vic, or they can be contacted on (03) 789 7354. (M.C.)



The output waveform at full load. Note the low distortion (around 3.5% for this level of loading).

50 and 25 years ago..

"Electronics Australia" is one of the longest running technical publications in the world. We started as "Wireless Weekly" in August 1922 and became "Radio and Hobbies in Australia" in April 1939. The title was changed to "Radio, Television and Hobbies" in February 1955 and finally, to "Electronics Australia" in April 1965. Below we feature some items from past issues.

Wireless Weekly 3d

December 1938

Single-ended pentodes: A new development which has taken place in the last few months, concerning valves for AC receivers has been the production of a new series of valves which for the first time have eliminated the familiar grid cap, characteristic of many American types since the first screen-grid valve, released years ago. At that time there were considerable difficulties in bringing the plate and control grid connections down to a common base, mainly because of inadequate shielding and the use of high capacity sockets. Design has progressed considerably since those days, and the problems of shielding, etc., are not now nearly as great.

RADIO, TELEVISION and HOBBIES

December 1963

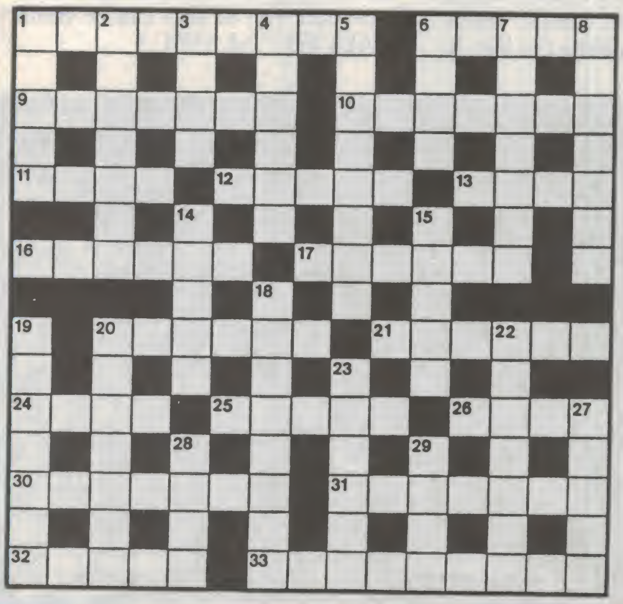
Black CRO for use in bright light: A new type cathode ray tube, using a transparent phosphor screen backed by a thin black backing layer, has been developed by the Hirst Research Centre of the General Electric Co. The main use for such screens is the display of information or pictures under normal bright lighting conditions.

Manufacture of the transparent screen is by vacuum desposition. When sufficient phosphor has been deposited, but while it is still transparent, the tube is baked and the phosphor coated with a black backing material.

This black layer absorbs, any light which falls upon the screen (the screen appears black) and also prevents the observer from seeing the hot cathode. In addition, the thin screen minimises definition loss due to light scatter within the screen layer.

IRE becomes IREE: A few weeks ago, members of The Institution of Radio Engineers, Australia, voted to change the name of their group to The Institution of Radio and Electronic Engineers, Australia. It was pointed out, by way of explanation, that the term "radio" is no longer adequate to describe a science, which has spread far beyond the original concept, to invade almost every aspect of modern science and technology. Nowadays, no matter what the investigation, or what the job in hand, there is a good chance that an electronics expert will not be far away, with his valves and transistors and all the associated gadgetry.

CROSSWORD



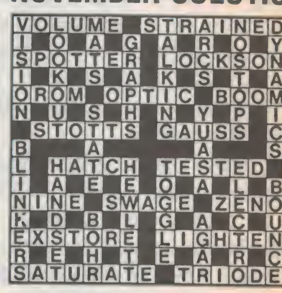
ACROSS

1. Charge holder. (9)
6. Control on a CRO. (5)
9. Which organic system has electric pulses? (7)
10. Searching device. (7)
11. Soldering points. (4)
12. Concerned with our natural satellite. (5)
13. Another name for the electron as a particle. (4)
16. Upper section of audio spectrum. (6)
17. Block view of planet. (6)
20. Nature of CB radio. (3-3)
21. Metalworker's electric appliance. (6)
24. Communication between stations. (4)
25. Historic outback system, ---- radio. (5)
26. Refracting device. (4)
30. Such temperatures are positively cold! (3-4)
31. Instrument using beams to measure angles. (7)
32. Searched for listening bugs. (5)
33. Varied a signal's characteristics. (9)

DOWN

1. Channel for shipping traffic. (5)
2. Closest point in a satellite's orbit. (7)
3. Render inoperative by thermal overload. (4)
4. Group of cells in organ. (6)
5. Rigorous investigation for new facts. (8)
6. Sender in semaphore. (4)
7. The EA/DSE Grand Aussie Hobby Electronics ----. (7)
8. Type of mounting. (7)
14. High-level scientific programming language. (5)
15. Melted. (5)
18. Display usually seen on a CRO. (8)
19. Books showing Landsat data. (7)
20. Capable of being adjusted to optimum setting. (7)
22. Formed by a moulding technique. (7)
23. Device for position determination. (6)
27. Two main computer requirements, memory capacity and ----. (5)
28. Stereo channel. (4)
29. Make a circuit dead. (4)

NOVEMBER SOLUTION



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